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SOUTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

Public Health Service
Kansas City, Missouri

July 1950

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Federal Security Agency
Public Health Service
Environmental Health Center
Cincinnati, Ohio

and

Missouri River Basin Office
Water Pollution Control Division
Kansas City, Missouri
July 1950

REPORT

SOUTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

Prepared by the Public Health Service at the request of and in cooperation with the Bureau of Reclamation, the Colorado State Department of Public Health, and the City and County of Denver, Colorado.

Details of illustrations in
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This report has been reviewed and concurred in by the State Water Pollution Control Agencies of Colorado, Wyoming, and Nebraska, and the Bureau of Health and Hospitals, City and County of Denver, Colorado. Acknowledgment is also made of review by the Bureau of Reclamation, Department of the Interior; Corps of Engineers, U. S. Army; and the Fish and Wildlife Service, Department of the Interior.

SOUTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

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INTRODUCTION

The water resources of the South Platte River Basin have been developed to an unusual degree of completeness with the result that the economy of the Basin is highly dependent upon the continued availability of the limited water supply of the area. Abatement of pollution had not kept pace with other aspects of water resource development, and degradation of water quality adversely affected important water uses, particularly the truck garden type of irrigation farming which is extensively developed in the area. The Bureau of Reclamation recognized the over-all relationship of water pollution and water resource development in the Basin and the ensuing study of the Blue-South Platte River Project Report by Regional Office IX, Public Health Service, revealed that available data were inadequate to properly relate the significance of pollution with water use. Consequently, negotiations were inaugurated with the Bureau of Reclamation regarding a comprehensive investigation of water pollution to encompass the entire South Platte Basin as a cooperative activity of the Bureau of Reclamation and the state, local and federal agencies. The initial discussions relative to such a study were conducted by Sanitary Engineer Director C. H. Atkins, then Regional Engineer, and Assistant Surgeon General J. O. Dean, then Regional Medical Director, Region VII, U. S. Public Health Service, and Regional Director Avery A. Batson, Region No. 7, Bureau of Reclamation. Sanitary Engineer Director M. LeBosquet, Jr., Director of Field Activities, Environmental Health Center, Public Health Service, participated in the basic planning of the study. Final arrangements were handled by the Missouri Drainage Basin Office, Division of Water Pollution, Public Health Service. In July 1948, a formal "Memorandum of Understanding" was executed. This agreement provided for collaboration between the Bureau of Reclamation, the Colorado State Department of Public Health, the Denver City Health Department, and the Public Health Service, in a study of the water pollution situation in the South Platte River Basin. The agreement specified the cooperative activities and financial assistance to be provided by the various agencies named. The full text of this agreement is presented in Appendix "A."

The Public Health Service acknowledges with thanks the active assistance and friendly cooperation of all of the other agencies involved in this study.

This report is presented in accordance with paragraph 4(a) of the original agreement and covers the full period of operations from August, 1948 through December, 1949.

ACKNOWLEDGMENT

Acknowledgment is made of the excellent support of the Bureau of Reclamation - the South Platte River District and the Regional Office, Region 7. Additional material was obtained from the U. S. Engineer Department - Denver District Office. The assistance of the State Health Departments, especially Colorado which contributed directly to the investigation as a party to the Memorandum of Understanding, is acknowledged. Material support was obtained from the Colorado Game and Fish Department which contributed the service of two sample collectors to the project. The assistance rendered by the City and County of Denver was of considerable value to the outcome of this investigation. Special acknowledgment is made of the invaluable contributions made to the progress of the survey by the City of Greeley, Colorado; the Colorado Agricultural and Mechanical College of Ft. Collins, Colorado; the Denver Water Board; and the City of Ogallala, Nebraska.

Assistance rendered by the Region 9 Office, Federal Security Agency and by the Colorado State Engineer and the U. S. Geological Survey is also gratefully acknowledged.

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SOUTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

SYLLABUS

This investigation was undertaken by the Environmental Health Center, Public Health Service, for the Bureau of Reclamation, Department of the Interior, in accordance with a "Memorandum of Understanding Respecting Joint Program for Stream Pollution Investigations of the South Platte River Basin," executed July 20, 1948.

Preliminary operations were started in late August, 1948, and routine operations on a basin-wide scale were under way in January, 1949, and continued through December, 1949.

The South Platte River Basin embraces some 24,030 square miles, 19,022 of which are in Colorado; 3,011 of which are in Nebraska; and 1,997 of which are in Wyoming. About 23% of the basin area lies at elevations from about 8,700 to 14,000 feet; 47% lies in the piedmont regions at elevations from 3,000 to 6,000 feet; and the remainder is in the high plains region at elevations from 6,000 to 8,000 feet.

The stream lies in a semi-arid region with average annual rainfall in the plains area of about 13 inches. Temperatures have a wide range. Relative humidities are low.

Total basin population in 1940 was 665,644, 90% of which was in Colorado, and the remainder divided about equally in Nebraska and Wyoming. Of the 1940 population, about 67% was urban and 33% was rural. It is estimated that the basin population had increased to 754,000 in 1949.

Present average annual basin water supply from all sources is about 2,800,000 acre-feet. Projects now under construction, or in the planning stage, will greatly increase the transmontane diversion supply. The Colorado-Big Thompson Project (Exhibit I) will supply about 300,000 acre-feet, and the Blue-South Platte River Project (Exhibit II) will supply 430,000 acre-feet.

The major water usage in the basin is for irrigation. In 1940, approximately 418,000 persons were served from surface water supplies. There are 23 communities using such supplies, most of which are obtained from headwaters of streams. Twelve communities, including Denver and Cheyenne, have filter plants. The remaining 11 communities use partially treated or untreated supplies.

Approximately 618,000 persons (1949 census) are served by sewer systems discharging raw or treated sewage into the streams of the South Platte river system. About 9% of this number was dischargeing raw sewage while the sewage from the remainder received some type of treatment. Sewage from about 80% of the population receives primary treatment and only about 11 per cent has secondary treatment About 69% of the sewered population is located in the Denver area.

Major effects of pollution in the basin are those which affect the quality of the waters so as (1) to limit their usage for irrigation, (2) to restrict their use for recreational purposes, including fishing, (3) to create local nuisance conditions in certain areas at certain times, and (4) to limit industrial usage for certain purposes. In order to better evaluate some of these factors, special studies of the irrigation problems and of the wastes produced by the beet sugar industry in the basin were undertaken during this investigation.

The City of Denver constitutes the largest single sewage disposal problem in the basin simply because of its size. However, acute sewage disposal problems are found below Golden, Boulder, and Greeley, and to a much lesser extent below Longmont and Loveland. The major industrial waste problem concerns the disposal of wastes from beet sugar processing. Although wastes from canneries, dairy products, meat processing, and other industries contribute to the over-all pollution of the streams in the basin, they do not have the profound effects such as are produced in the basin streams by the wastes from the sugar industry during the campaign.

In general, the heaviest pollution occurs in the central portion of the basin where the population concentration is heaviest. Relatively little pollution is found in the high mountain regions or in the lower plains area below Ft. Morgan.

Pollution as a major factor influencing surface water supplies is of small importance in the basin picture No public water supplies are taken directly from streams below the major population centers and none are taken directly from the entire length of the South Platte below Denver. The major source of water for communities in the plains area is ground water.

ORGANIZATION, OBJECTIVES, AND SURVEY METHODS

Organization

Under the terms of the Memorandum of Understanding, the Public Health Service initiated the pollution survey of the South Platte River Basin on August 25, 1948, following the arrival in Denver, Colorado on that date of personnel from the Environmental Health Center at Cincinnati, Ohio. Stream sampling operations were begun in October, 1948.

Fixed laboratories were established at Denver and at Greeley in cooperation with the Colorado State Department of Public Health and the City of Greeley. A mobile laboratory unit was supplied by the Public Health Service and was used in those portions of the basin not reached from the two fixed installations. The Greeley laboratory and the mobile unit were staffed by Public Health Service personnel. The laboratories at Denver were those of the Colorado State Health Department. Through a cooperative agreement between the Colorado State Game and Fish Department and the Colorado State Department of Public Health, sample collectors for the Greeley and Denver laboratories were employed by the State Game and Fish Department. (See supplementary agreement, Appendix "A".) The mobile laboratory unit was established at Ft. Collins, Colorado through the courtesy of the Colorado A & M College and alternated between this location and one established at Ogallala, Nebraska throughout the course of the stream sampling operations between May and December, 1949.

Objectives

The objectives of this survey are set forth in the second paragraph of the Memorandum of Understanding (Appendix "A"). These objectives may be restated as follows:

1. Determination of the extent, types, and major sources of pollution in the basin.

2. A review of existing state laws in Colorado, Wyoming, and Nebraska and pending legislation regarding pollution of public waters.

3. Determination of the sanitary quality of water for irrigation uses at present and at proposed diversion points and in existing canals.

4. Minimum stream flows necessary below the reservoirs for public water supplies and for sanitation purposes with present and contemplated pollution loads.

5. Public water supply needs.

6. Possible benefits to the abatement of water pollution problems by reservoir releases.

7. Recommendations and existing plans for pollution abatement.

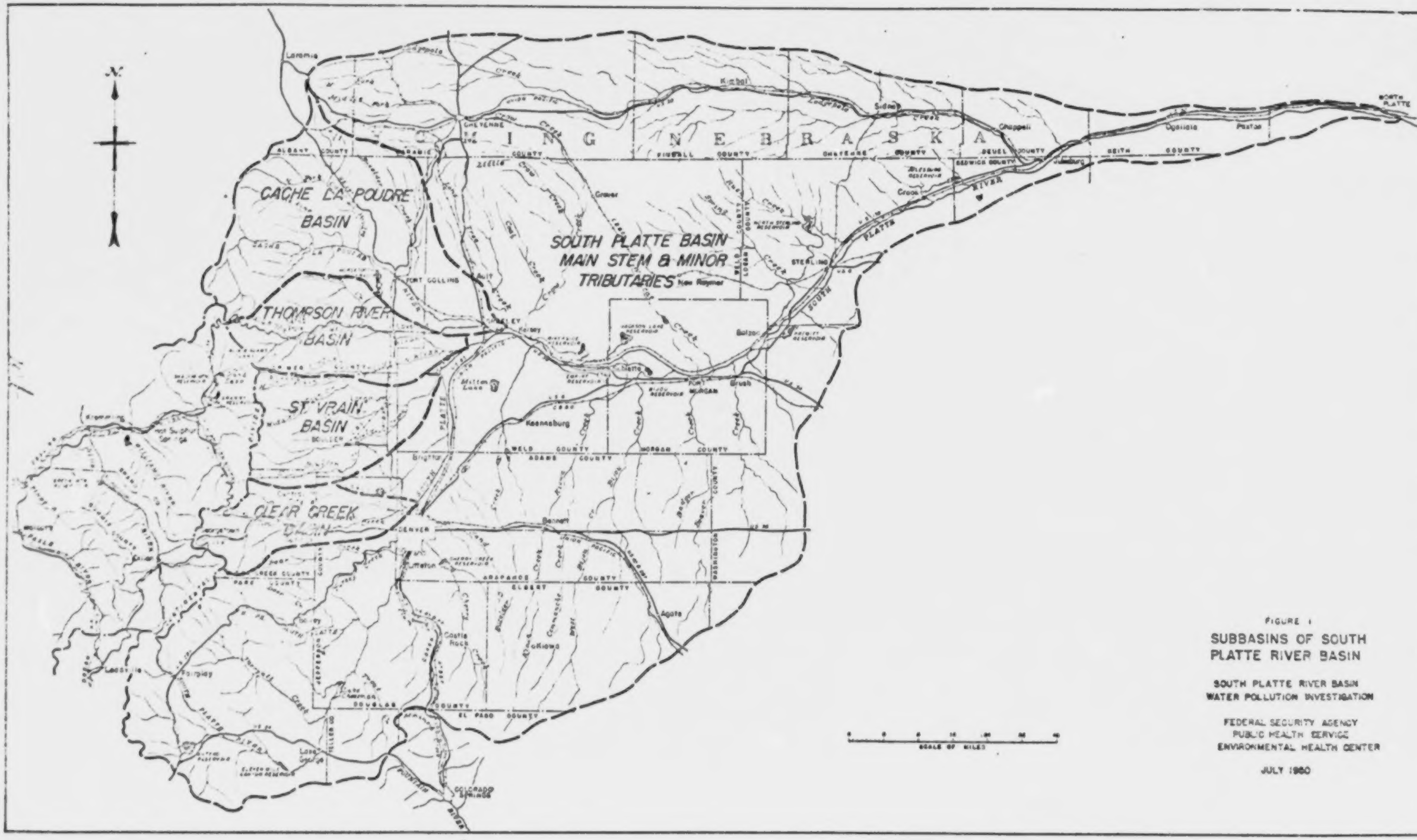


FIGURE 1

SUBBASINS OF SOUTH PLATTE RIVER BASIN

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER

JULY 1950

In view of the objectives as outlined above, the following activities were carried out in order to achieve the desired ends:

1. Determination of the extent, types, and major sources of pollution, and the sanitary quality of the water as applied to irrigation and other uses.

(a) A comprehensive sampling of the streams and diversion ditches throughout the basin at strategic locations for the purposes of determining the sanitary quality of the water as measured by the following laboratory tests:

(1) Bacterial quality as determined by the coliform test.

(2) Dissolved oxygen.

(3) Biochemical oxygen demand.

(4) Physical tests - temperature, turbidity.

(5) Chemical tests - pH, alkalinity, hardness, copper, etc.

(b) Physical inventory of all sources of pollution throughout the basin.

(c) Examination of industrial wastes where necessary to determine their effects.

(d) Stream flow records.

2. Review of state laws regarding pollution of streams.

3. Determination of minimum stream flows below reservoirs (a) for public water supplies, and (b) for sanitation purposes with present and contemplated pollution.

While not specifically mentioned in the original agreement, a bacteriological study of the use of polluted water for irrigation of truck crops was undertaken. This investigation was believed necessary in order to assist in the evaluation of the results of the actual pollution survey work. However, the very limited extent to which the study could be carried out during the course of this survey did not permit the procurement of conclusive evidence upon which to base any valid conclusions. A report of this study is presented in Appendix "G". This study will be continued. In addition, an epidemiological study of the public health problems associated with irrigation waters affected by pollution will be undertaken.

Methods

The data collected during this investigation may be divided into the following categories:

1. Data on sources and types of pollution.
2. Laboratory data.
3. Hydrometric data.
4. Special Studies.

The methods used and the status of the data obtained are as follows:

Data on Sources and Types of Pollution

Preliminary data were assembled from various available sources which included both published and unpublished material. Data on sources of pollution are presented in Tables 16 through 27. Table 17 lists all communities in the basin showing their status with regard to sewage disposal. The basic data for this table were obtained from the "Inventory of Water and Sewage Facilities in the United States" (1945), supplemented by data from the "Nationwide Survey of Sanitation Needs" (1946), and by actual field investigations made by engineering personnel engaged on this study. Tables 19 through 27 were compiled from data obtained from an industrial waste survey of the Platte River Basin carried out by personnel engaged on this investigation. Production figures were obtained as of the time of the survey and strengths of the wastes, except in a few instances, were obtained from various published data sources. Industrial waste data for the City of Denver were obtained from the City of Denver and include only those industries actually within the city limits. The report prepared by the City of Denver is presented in Appendix "C." In the case of the beet sugar industry, some oil refineries, and in a few scattered individual instances, strengths of the wastes being discharged to the stream were the subject of special investigations carried out for this purpose. The report on the beet sugar wastes investigations is presented in Appendix "F." Sample reports for other industries are shown in Appendix "D." Figure 3 shows the location and approximate magnitude of various sources of sewage pollution contributed to the South Platte River Basin. Industrial pollution, as shown, is based upon equivalent population.

Laboratory Data

The laboratory data were obtained from physical, chemical, and bacteriological tests on samples of water from 135 sampling points in the South Platte Basin. Sampling points were located so as to give a representative picture of the water quality in respect to various parts of the basin under various seasonal conditions. Table 1 shows the main sampling station locations, and Figure 2 shows the general areas of the basin covered by each laboratory during the course of the investigation. Table 3 summarizes the stream analyses conducted by the various laboratories in tabular form. In addition to the stream sampling, there were three closely allied investigations conducted during the time of this survey, (1) a comprehensive beet waste study at Loveland, Windsor, and Brighton, (2) a study of the Denver Sewage Treatment Plant, and

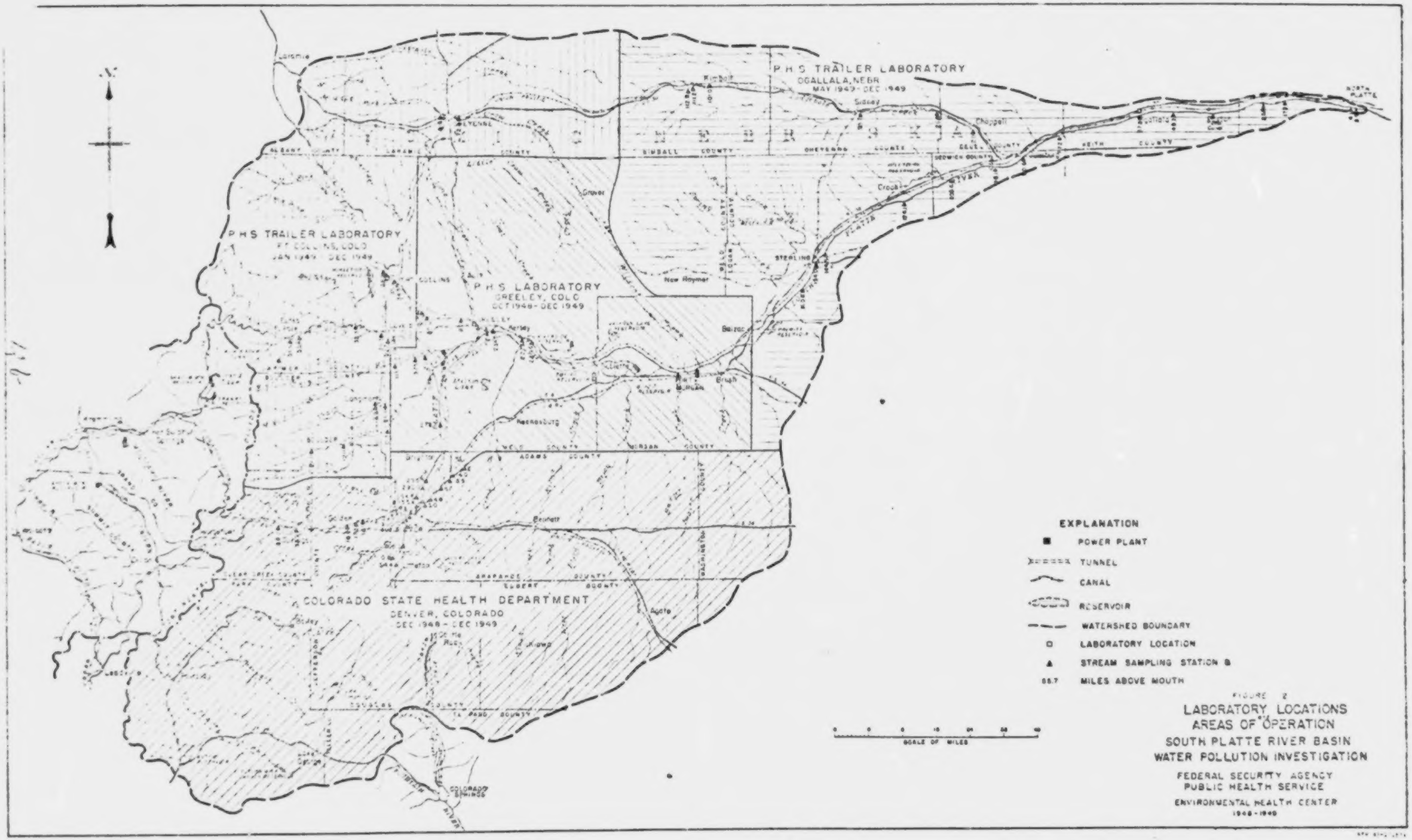


FIGURE 2

LABORATORY LOCATIONS
AREAS OF OPERATION
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER
1948-1949

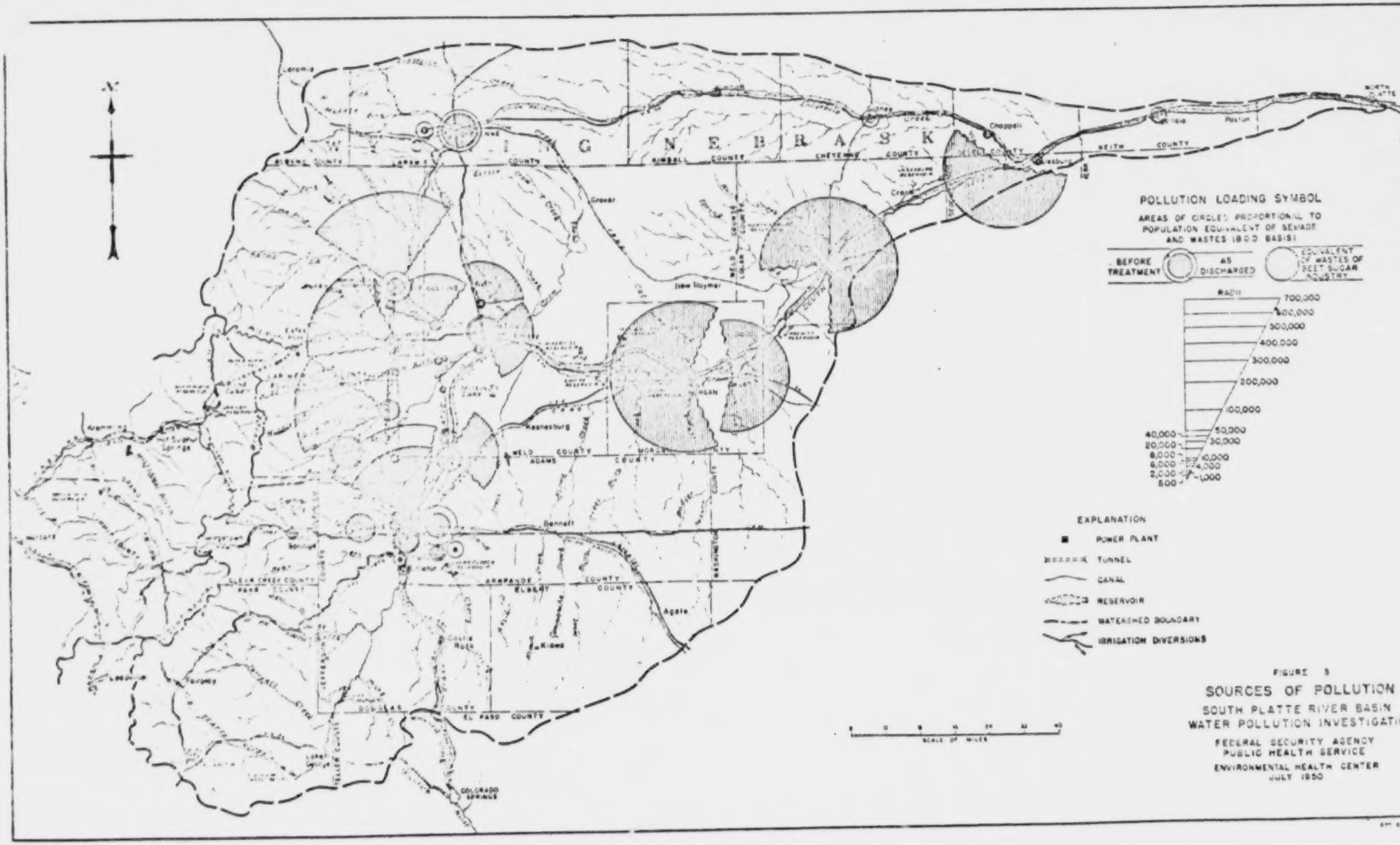


FIGURE 3

SOURCES OF POLLUTION

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

Table 1

List of Sampling Stations
South Platte River Basin Water Pollution Investigation

Station Designation	Stream Mileage above Mouth		Description
	Main Stem	Tributary	
South Platte River			
SP 314.4	314.4		Bridge at Littleton, Colo. gage
SP 309.3	309.3		Bridge at Evans Ave., Denver
SP 302.3	302.3		19th Street gage, Denver
SP 300.0	300.0		40th Street bridge, Denver
SP 299.L	299.0		Downing St. bridge, Denver
SP 299.R	299.0		Downing St. bridge, Denver
SP 298.6	298.6		Burlington-O'Brian Canal intake
SP 298.2	298.2		Gardner's Ditch intake
SP 295.5	295.5		Bridge near Welby, Colorado
SP 294.2	294.2		Fulton Ditch intake
SP 292.0	292.0		Brantner Ditch intake
SP 286.7	286.7		Bridge at Henderson, Colorado
SP 284.0	284.0		Bridge at Brighton, Colorado
SP 277.0	277.0		Bridge at Wattenberg, Colorado
SP 272.2	272.2		Ft. Lupton gage
SP 247.8	247.8		Twin Bridge on State Route 60
SP 247.7	247.7		Union Ditch intake
SP 234.5	234.5		County Road above Cache la Poudre
SP 227.5	227.5		Riverside Canal intake
SP 226.9	226.9		Bridge on County Road 4 Mi. E. of Kersey
SP 226.8	226.8		Empire Ditch intake
SP 217.6	217.6		Bijou Canal bridge on Hwy 34
SP 210.0	210.0		Sublette, Colorado bridge N. of Hwy 144
SP 183.8	183.8		About 1 Mi. below Hwy bridge at Ft. Morgan
SP 178.4	178.4		Lower Platte and Beaver Canal
SP 177.8	177.8		Bridge on State Hwy 34
SP 160.8	160.8		Bridge on State Hwy 63, Atwood, Colo.
SP 155.4	155.4		Cole Extension Ditch, bridge on U.S. Hwy 6
SP 155.1	155.1		Sterling No. 1 Canal, bridge on Hwy 138
SP 153.0	153.0		Bridge on U.S. Hwy 6, Sterling, Colo.
SP 144.5	144.5		Bridge on State Hwy E. of Ford, Colo.
SP 124.1	124.1		Bridge on State Hwy 25 at Crook, Colo.
SP 105.6	105.6		Bridge on State Hwy 59, Sedgwick, Colo.
SP 103.6	103.6		Peterson Canal intake
SP 98.1	98.1		Bridge on State Hwy 23, Ovid, Colo.
SP 90.0	90.0		Bridge on State Hwy 51, Julesburg, Colo.

Table 1 (Cont'd)

Station Designation	Stream Mileage above Mouth		Description
	Main Stem	Tributary	
South Platte River			
SP 84.5	84.5		Western Canal intake
SP 77.2	77.2		Bridge on Hwy S. of Big Springs, Neb.
SP 57.2	57.2		Bridge on Hwy S. of Ogallala, Neb.
SP 56.7	56.7		Hollingsworth Canal intake
SP 49.2	49.2		Bridge on Hwy S. of Roscoe, Neb.
SP 23.8	23.8		Bridge on Hwy S. of Sutherland, Neb.
SP 17.2	17.2		Bridge on Hwy S. of Hershey, Neb.
SP 4.0	4.0		Bridge on Hwy S. of North Platte, Neb.
Power Canal			Siphon outlet S. of Paxton, Neb.
Sutherland Res.			Outlet Canal Sutherland Reservoir
SP 3.5	3.5		Tailrace Ditch, North Platte Power Plant
P 0.5			Platte River-Supply Canal intake
Bear Creek	311.3		Junction with South Platte River
Be 0.8		0.8	Bridge at gage near mouth
Cherry Creek	302.8		Junction with South Platte River
Ch 1.0		1.0	Bridge at Lawrence St., Denver
Burlington-O'Brian Canal	298.6		Burlington-O'Brian Canal intake
B-O'B 0.5		0.5	Bridge at York Street, Denver
B-O'B 3.0		3.0	Bridge on County Road W. of Adams City
B-O'B 4.8		4.8	Bridge at Dupont
B-O'B 8.7		8.7	Bridge on County Road W. of U.S. Hwy 6
B-O'B 10.5		10.5	Bridge on County Road near Eno
B-O'B 14.0		14.0	Inlet to Barr Lake Reservoir
Barr Lake (West)			Speer Canal outlet (Barr Lake)
Barr Lake (East)			Neres Canal outlet (Barr Lake)
Clear Creek	296.0		Junction with South Platte River
Cl 38.5		38.5	Bridge at W. edge of Idaho Springs
Cl 33.2		33.2	Bridge on U.S. Hwy 40 E. of Idaho Springs
Cl 18.0		18.0	Bridge at W. edge of Golden, Colo.
Cl 17.5L		17.5	Wanamaker Ditch intake
Cl 17.5R		17.5	Lee, Stewart & Eskins Ditch intake
Cl 16.1		16.1	Rocky Mountain Ditch intake
Cl 3.4		3.4	Lower Clear Creek & Colorado Agricultural Canal
Cl 0.8		0.8	Bridge on County Road near mouth

Table 1 (Cont'd)

Station Designation	Stream Mileage above Mouth			Description
	Main Stem	Tributary		
St. Vrain Creek	253.4			Junction with South Platte River
SV 38.9		38.9		Supply Canal intake
SV 38.4		38.4		Highland & Rough & Ready Canal intake
SV 29.5		29.5		Bridge on Hwy 1½ Mi. W. of Longmont
SV 27.5		27.5		Bridge on U. S. Hwy 87, S. of Longmont
SV 26.0		26.0		Bridge on Hwy 1½ Mi. E. of Longmont
SV 25.0		25.0		Bridge on Hwy 2½ Mi. E. of Longmont
SV 23.0		23.0		Bridge on State Hwy 185
Boulder Creek		17.4		Junction with St. Vrain Creek
SV-Bo 28.5			28.5	Gage above Fourmile Creek
SV-Bo 26.0			26.0	Bridge on Hwy 119, W. of Boulder
SV-Bo 21.0			21.0	Beasley-Boulder & Lefthand Canal Intake
SV-Bo 19.0			19.0	Bridge on Hwy 7, E. of Boulder
SV-Bo 15.0			15.0	White Rock Ditch intake
SV-Bo 14.5			14.5	County Road N.E. of Boulder
SV-Bo 6.0			6.0	Junction of Coal Creek
SV-Bo-Co 0.1			0.1	Coal Creek at mouth
SV 3.6		3.6		First bridge about mouth of St. Vrain Creek
Thompson River*	244.9			Junction with South Platte River
T 62.0		62.0		Outlet of Adams Tunnel
T 56.0		56.0		Bridge on Hwy 66, Estes Park
T 53.8		53.8		Outlet - Olympus Dam
T 32.3		32.3		Loveland Water Works intake
T 32.3		32.3		Handy Ditch intake
T 26.3		26.3		Bridge on County Road 2 Mi. W. of Loveland
T 24.3		24.3		Greeley Canal intake
T 23.3		23.3		Farmer's Ditch intake
T 22.7		22.7		Bridge on County Road 2½ Mi. E. of Loveland
T 17.9		17.9		Hillsboro Ditch intake
T 15.9		15.9		Bridge on State Hwy 185
T 9.9		9.9		Bridge on State Hwy 259
T 8.5		8.5		Big Thompson Canal intake
Little Thompson		6.4		Junction with Thompson River
LT 11.0			11.0	Bridge 1 Mi. E. of Larimer-Weld County line
LT 7.0			7.0	Minor's Ditch intake
LT 3.8			3.8	Bridge 1½ Mi. S.W. of Johnstown
LT 2.0			2.0	Bridge 1 Mi. E. of Johnstown
T 2.9		2.9		Second bridge above mouth of Thompson

* Official name "Big Thompson River"

Table 1 (Cont'd)

Station Designation	Stream Mileage above Mouth		Description
	Main Stem	Tributary	
Cache la Poudre	233.9		Junction with South Platte River
ClP-NF 14.0		14.0	North Poudre Canal intake
ClP 49.8		49.8	Poudre Valley Canal intake
ClP 41.0		41.0	Larimer & Weld Canal intake
ClP 38.8		38.8	Bridge on U.S. Hwy 87, Ft. Collins
ClP 36.5		36.5	Timnath Reservoir intake
Timnath			Timnath Reservoir outlet
ClP 35.5		35.5	Spring Creek mouth
ClP 35.0		35.0	Bridge on State Hwy 260
ClP 34.3		34.3	Fossil Creek Reservoir intake
Fossil Creek Res.			Fossil Creek inlet (west)
Fossil Creek			Fossil Creek Reservoir outlet
ClP 32.0		32.0	Bridge on State Hwy 185
ClP 21.8		21.8	Bridge on State Hwy 259
ClP 21.3		21.3	Ford above sugar factory, Windsor
ClP 21.0		21.0	Sugar factory lagoon outlet
ClP 20.0		20.0	Bridge on State Hwy 257
ClP 14.4		14.4	Greeley Ditch #3 intake
ClP 9.0		9.0	Bridge on County Road 2 Mi. W. of Greeley
ClP 4.3		4.3	Bridge below Greeley Sewage Treatment Plant
ClP 4.0		4.0	Ogilvy Ditch intake
ClP 2.6		2.6	First Bridge above mouth of river
Crow Creek	227.8		Junction with South Platte River
Cr 81.6		81.6	Bridge at Ft. Warren, Wyo.
Cr 77.0		77.0	Bridge on U.S. Hwy 85-87, Cheyenne, Wyo.
Cr 76.3		76.3	Storm sewer outlet, Cheyenne, Wyo.
Cr 76.0		76.0	Below sewer outfall, Cheyenne, Wyo.
Cr 72.5		72.5	Outlet below sewage lagoons, Cheyenne
Lodgepole Creek	98.4		Junction with South Platte River
Lod 112.8		112.8	Inlet to Oliver Reservoir, Bushnell, Neb.
Lod 111.2		111.2	Oliver Reservoir outlet
Lod 101.0		101.0	Bennett Reservoir inlet
Lod 100.3		100.3	Bennett Reservoir outlet
Lod 55.7		55.7	Below Sewage Treatment Plant, Sidney, Neb.
Lod 26.8		26.8	Bridge on County Road S. of Lodgepole, Neb.
Lod 12.0		12.0	Bridge S. of Chappel, Neb.
Lod 0.5		0.5	Bridge on Hwy 138 at Ovid, Colorado

TABLE 2

Stream Sampling at Various Laboratories
South Platte River Basin Water
Pollution Investigation

Laboratory Location	Operations began -date-	Streams Covered	Number Samples Examined	Number Determinations Made
P.H.S. Laboratory, Greeley, Colo. (Greeley Sewage Treatment Plant)	10-19-48	So. Platte River Cache LaPoudre R. Thompson River Little Thompson R. St. Vrain Cr. Mouth	1,501	10,978
P.H.S. Trailer Unit, Ft. Collins, Colo. and Ogallala, Nebraska	1-6-49	So. Platte River St. Vrain Creeks Thompson River Boulder Creek Crow Creek Lodgepole Creek	957	7,000
State Health Dept. Laboratories, Denver, Colorado	12-22-48	So. Platte River Bear Creek Clear Creek Burlington Ditch Cherry Creek	701	3,505
TOTALS			3,159	21,483

Table 3 Various Physical, Chemical and Bacteriological Examinations Used in South Platte River Basin Water Pollution Investigation

TEST	REASON
	Physical and Chemical
1. Temperature	Influences solubility of oxygen and rate of self-purification.
2. Turbidity	Index of silt or other suspended matter density.
3. pH	A measure of the concentration of hydrogen ions in the water.
4. Alkalinity	Represents content of carbonates, bicarbonates, hydroxides and sometimes borates, silicates, and phosphates.
5. Soap Hardness	Measures the soap consuming power of the water. Gives a rough measure of the concentration of hardness producing minerals (principally calcium and magnesium) in the water.
6. Dissolved Oxygen	Necessary to natural purification of streams and essential for fish and other aquatic life. Supports biochemical oxidation of organic wastes. Is replaced by absorption from atmosphere or from photosynthetic action of some water plants, including algae. Polluting organic substances which absorb oxygen from the stream depress the dissolved oxygen below the saturation level. The degree of this depression is a measure of the de-oxygenation effect of the polluting matter and is therefore a measure of the degree of pollution present.
7. 5-day BOD at 20° C.	Indicates the amount of dissolved oxygen which may expect to be absorbed from the stream water in 5 days at 20°C in order to support the biochemical oxidation of the organic pollution carried by the stream at the point of sampling. (BOD = Biochemical Oxygen Demand.)
8. Copper	The presence of this metal in significant amounts affects the biochemical oxygen demand (BOD) by limiting biological growths.
	Bacteriological
9. Coliform bacteria (determined by standard confirmed fermentation tube test at 37°C.)	This test is the most delicate and specific test for pollution by sewage as it shows the approximate density of a group of bacteria which are always present in large numbers in sewage. Coliform bacteria are normal inhabitants of the intestinal tracts of warm blooded animals and are discharged in large numbers in human feces, which constitute the principal source of these bacteria in sewage.

(3) bacteriological studies on irrigated fruits and vegetables. The latter two studies have not yet been completed.

Table 3 presents a summary of the various tests made on the stream samples collected during the course of the investigation and briefly outlines the reason for each test. These determinations were made in conformance with the requirements and procedures as outlined in the "Standard Methods for the Examination of Water and Sewage" (9th Edition, 1946), published jointly by the American Public Health Association and the American Water Works Association.

Hydrometric Data

Stream flow data were obtained from the Bureau of Reclamation. Wherever possible, stream sampling stations were located at or near established gaging stations. This was often possible along the main stream and at tributary mouths. Samples from irrigation ditches and canals were taken as close to the measuring weirs or flumes as was possible without interfering with sample requirements. In all cases where established gages were not available for the measurement of stream flows, the Bureau of Reclamation installed staff gages and made actual measurement at the section. Sample collectors recorded gage readings and time of sampling when collecting from any station. These data were transmitted to the Hydrometric Data Section of the South Platte River District, Bureau of Reclamation, for translation into stream or canal flow at the sampling point at the time of sampling.

Table 9 presents a summary of published stream flow data for the South Platte River and upper tributaries. This table was compiled by the Corps of Engineers, U. S. Army, Denver District Office. Table 10 lists all gaging stations operating in the South Platte River Basin during the time of this survey.

Additional hydrometric data showing the estimated effects of project operations upon the stream flows at various gaging points on the main stem and at certain points on the tributaries were compiled by the Bureau of Reclamation in order to provide some basis for estimating the probable future effects of reservoir operations and irrigation return flows on the streams in the basin. (See Appendix "H")

Special Studies

During the course of the investigation, several special studies were made which clarify certain aspects of the basin pollution picture. These studies with the exception of the Denver Sewage Treatment Plant investigations are the subject of several appendices to the report and are described fully therein. A brief summary of each is presented as follows:

Bacteriological Study of Irrigation Waters Subject to Pollution and of Crops Irrigated with Such Waters - This study was a separate undertaking under the direction of Sanitarian Noah N. Norman. Field Operations were begun in July 1949 and continued through the 1949 irrigation season. Limitation of funds and personnel restricted the scope of the study and the results obtained, while indicating trends, were by no means conclusive. A report of the study for the 1949 season appears in Appendix "G." It is anticipated that the study will continue with increased funds and personnel at least during the 1950 season.

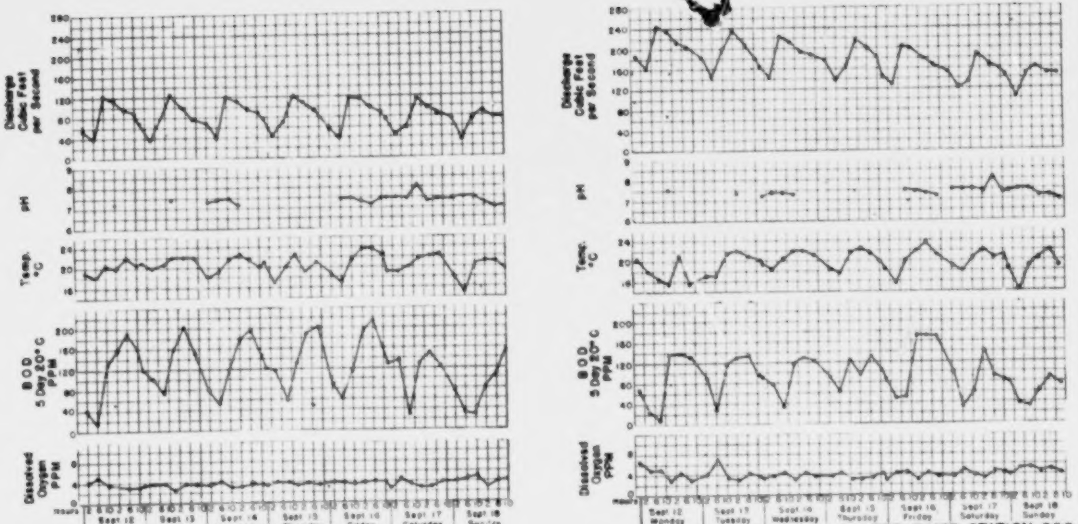
Beet Sugar Factory Waste Studies - In cooperation with the Great Western Sugar Company, a series of investigations were undertaken on the character of, and possible treatment for, wastes resulting from beet sugar processing. Studies of constituent wastes were made at a straight house factory at Windsor, Colorado, and at a Steffens house factory at Loveland, Colorado. In addition, attempts were made to study screening and lagooning of wastes at Windsor plant. These studies are reported in Appendix "F." They were carried out under the direction of Sanitary Engineer Graham Walton during the processing season, October-December, 1949.

A study was also conducted on pilot plant scale at the Brighton, Colorado, factory on the chemical treatment of pulp waters. This study was made during the processing period, October-December, 1949, and was in charge of Sr. Asst. Sanitary Engineer G. N. McDermott. The results are presented in Appendix "F." Results of past studies of a similar character made elsewhere were corroborated and suggestions for subsequent waste studies were made.

Denver Sewage Treatment Plant Studies - Two separate investigations were made involving the Denver Sewage Treatment Plant.

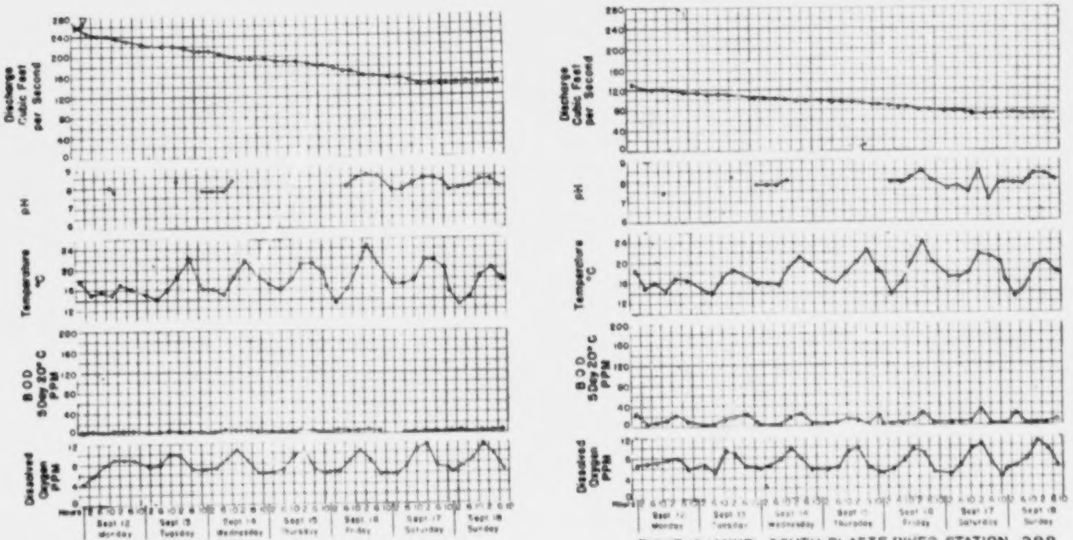
The first was made in September, 1949, and involved the variations in loading of the stream by discharge of the plant effluent throughout the 24-hour period of each day for a complete 7-day weekly period. This study was to correlate the maximum loading with the time of sampling the stream during routine stream sampling operations. Results indicated that stream samples were taken during periods of maximum loading. The results of this study are shown graphically in Figure 4.

The second study was of a different nature and involved a longer period of time from January through March, 1950. The objects of this study were to evaluate the over-all plant efficiencies and to determine, if possible, the improvement attributable to the use of the "Gunson Process," developed at the Denver plant by Mr. C. P. Gunson. Overloading of the present plant and construction of the new additions to the present plant did not permit an entirely fair test of the process, but the figures for over-all plant efficiency during the period under the conditions encountered were of value in estimating the plant loading at that time. Results of this study have not yet been completely analyzed.



DENVER SEWAGE TREATMENT PLANT EFFLUENT

LEFT CHANNEL SOUTH PLATTE RIVER STATION 299



SOUTH PLATTE RIVER STATION 300

RIGHT CHANNEL SOUTH PLATTE RIVER STATION 299

LEGEND

O - Observed Data

X - Depleted B.O.D. Result, Indicates Minimum Value

FIGURE 4

DAILY VARIATIONS IN B.O.D. AND D.O.

IN THE SOUTH PLATTE RIVER ABOVE AND BELOW
DENVER SEWAGE TREATMENT PLANT

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

HISTORICAL BACKGROUND

The South Platte River is a part of the Missouri River Drainage Basin and was included in the territory obtained from France by the Louisiana Purchase in 1803. The stream arises in the frontal range of the Rocky Mountains in Colorado and flows through a semi-arid plains region to its junction with the Platte River at North Platte, Nebraska.

The first known Europeans to visit the area were the Spanish explorers in the Sixteenth and Seventeenth Centuries. Their explorations did not result in settlement of the area. The region was inhabited by various tribes of Indians, such as the Kiowas and Utes, who followed a nomadic life and subsisted largely by hunting. Shortly after completion of the Louisiana Purchase, the United States sent expeditions into the territory to explore its boundaries and to report upon their findings. In 1806, Zebulon Pike reached the southern edge of the basin and discovered the mountain peak which now bears his name. In 1820, Major Stephen Long ascended the South Platte River to the Rocky Mountains. Two mountain peaks in the basin are named for members of this expedition: LongsPeak in Rocky Mountain National Park, and James Peak west of Denver. Members of this expedition made the first recorded ascent to the top of Pikes Peak.

About 1825, the demand for furs, especially beaver which was used largely in the manufacture of hats during that period, led the fur traders and trappers into the basin. This was the era of the now almost legendary Mountain Men, such as the Bent Brothers, Ceran St. Vrain, Louis Vasquez, Kit Carson, Jim Bridger, and others. These activities resulted in the establishment of trading posts and protective forts within the basin area.

The great westward migrations of the late Forties and early Fifties by-passed the region because of the difficult terrain and the more accessible passes to the north of the basin. The Oregon Trail, the Mormon Trail, and the California Trail passed to the north and followed the North Platte River to easier mountain passes in Wyoming, Utah, and Idaho. The Santa Fe Trail swung south of the basin following along the Arkansas River and turning south through Raton Pass into New Mexico.

In 1858, placer gold was discovered along the South Platte River near its junction with Cherry Creek and a gold rush was precipitated. Settlements were made on the present site of Denver and the region was organized as Arapahoe County, Kansas Territory, in that year. In 1859, a major gold strike was made on Clear Creek (North Fork) and the development of the basin began in earnest. Development in the Clear Creek, Boulder Creek, and Denver areas was rapid and settlement expanded down the South Platte River because those who failed in their quest for gold turned to farming and other means of livelihood. In 1861, the South Platte River above Julesburg was included within the newly organized Colorado Territory created by the Congress in that year. By this time there were many thriving communities throughout the basin.

The first railroad to enter the basin was the Union Pacific which followed along the South Platte River to Julesburg, Colorado, and hence westward through Nebraska along Lodgepole Creek and Crow Creek to Cheyenne, Wyoming. The first railroad to reach Denver was constructed southward from Cheyenne in 1870. The decade from 1870 to 1880 saw the construction of many independent rail lines in the South Platte Valley. Most of these railroads, many of which were narrow gage, were rather short lived and either have been abandoned, or have been absorbed into the present major rail networks.

By 1872, agricultural communities were well established throughout the entire South Platte River Basin. The use of water from the basin streams for irrigation was established by the first farming settlers. Irrigation in the western United States was first used by the Mormons at Salt Lake City in 1847. In Colorado, irrigation was first used in the San Luis Valley in 1852. Wyoming irrigation began in 1857. First diversions on the South Platte were made in 1859 in the vicinity of Denver. The rapid expansion of agriculture and the very limited water resources resulted in the establishment of the doctrine of appropriation as opposed to the idea of riparian ownership. Colorado was a leading state in the establishment of this doctrine now common to most of the western states.

Before 1890, importation of water from other basins into the South Platte Basin was begun. This has continued as water needs in the basin have become acute and water to satisfy them can be spared from other sources. At the present time, 1950, projects under construction or in the planning stage will supply an additional 600,000 acre-feet or more of water to the South Platte River Basin.

Since the turn of the century, mining, which gave the initial impetus to settlement of the basin, has declined in importance, and agriculture and manufacturing have now become the leading economic factors in the region. Manufacturing has developed steadily since 1900 and has had a rapid increase since 1940, largely as a result of World War II. Thus within the short space of one century, the transition from a region of virgin wilderness to one of modern agriculture and industry has occurred.

DESCRIPTION OF BASIN

Geography - Topography

The South Platte River arises in the extensive high, precipitous front ranges of the Rocky Mountains in Colorado, and flows for approximately 450 miles in a northerly and easterly direction to its confluence with the North Platte River at North Platte, Nebraska. The drainage area embraces 24,030 square miles, of which 19,022 are in Colorado, 3,011 are in Nebraska, and 1,997 are in Wyoming. Approximately 5,550 square miles of the basin (23%) lie in the mountain regions at elevations varying from 8,700 feet to over 14,000 feet; 11,340 square miles (47%) lie in the piedmont regions at elevations of 3,000 to 6,000 feet; and the remaining 7,140 square miles (30%) of the basin lie in the high plains regions at elevations varying from 6,000 to 8,000 feet above mean sea level. Figure 1 shows the drainage area of the South Platte River Basin.

Stream Characteristics

Stream velocities are swift as stream slopes are relatively steep. In the mountainous regions the slopes on the main stem and tributaries vary from maxima of over 1,000 feet per mile to minima of about 20 feet per mile. The average slope of the main stream in the plains area is about 8 feet per mile, with a maximum of 15 feet per mile immediately below Denver. Tributary streams arising in the plains area have average slopes varying from about 70 feet per mile near their sources, to about 14 feet per mile near their mouths. All tributaries draining the mountain regions are perennial streams which contribute heavily to the regular flow of the main stream. Plains tributaries are intermittent streams, but are often important contributors to spring and summer runoff. Mean annual recorded runoff of the South Platte River system at North Platte, Nebraska, is approximately 380,000 acre-feet. Table 4 compiled by U. S. Engineer Department, Denver Office, shows river mileages, drainage areas, channel elevations and slopes. These figures were used in computation of all stream mileage estimates.

Climatic and Hydrologic Features of the Basin

Temperature - Humidity - Evaporation

There is a wide range of temperatures. In winter, the average monthly mean temperatures are highest near the mountains. Recorded extreme temperatures from various stations in the basin show highs in excess of 100 degrees F. and lows of about -40 degrees F.

Table 5 gives the maximum and minimum recorded, average maximum, average minimum, and average mean annual temperatures for representative weather stations in the basin in Colorado.

The average growing season, the period free from killing frost, in the lower portion of the basin is 145 days and increases to 163 days at Denver and 165 days at Boulder. The shortest growing season in the plains area was 61 days at Fort Morgan in 1918, and the longest was 260 days at Boulder in 1901, which appears to be an extreme as the next longest growing season was 204 days at Denver in 1933. The average growing season in the mountains at Longs Peak is 61 days, where the shortest growing season of record was 3 days in 1910.

TABLE 4

River Mileages, Drainage Areas, Channel Elevations and Slopes

Location	Miles above mouth		Drainage area square miles	Elevations feet above mean sea level	Slope feet per mile
	Main Stream	Tributaries			
Main Stem of South Platte River					
Source	442.2			13,300	
Fairplay, Colo.	423.8		83	9,900	184.8
Mouth of South Fork	402.3			8,980	42.8
Mouth of Tarryall Cr.	363.7			7,410	40.7
South Platte, Colo.	335.6		2,550	6,078	47.4
Waterton, Colo. (gage)	327.4		2,611	5,484	72.4
Chatfield damsite	320.6		2,988	5,388	14.1
Littleton, Colo. (gage)	314.4		3,090	5,305	13.4
Denver, Colo. (19th St. gage)	302.3		3,840	5,162	11.8
Henderson, Colo. (gage)	286.7		4,792	5,005	10.1
Ft. Lupton, Colo. (gage)	272.2		5,108	4,889	8.0
End of proposed levee system (near mouth St. Vrain Creek)	252.1			4,727	8.1
Kersey, Colo. (gage)	231.9		9,500	4,575	7.5
Sublette, Colo. (gage)	210.0		12,269	4,420	7.1
Narrows damsite	192.5		13,397	4,310	6.3
Ft. Morgan damsite (alternate)	187.3		14,894	4,274	6.9
Balzac, Colo. (gage)	164.1		17.194	4,090	7.9
Ovid, Colo. (gage)	90.2			3,502	8.0
Mouth	0.0		24,030	2,790	7.9
Tributary Streams					
South Fork					
Source		33.0		11,900	
Above Lake Antero		20.3		9,060	139.9
Mouth	402.3	0	225	8,980	6.3
Tarryall Creek					
Source		48.4		11,950	
Mouth	363.7	0	460	7,410	93.8
N. Fork of S. Platte R.					
Source		47.4		12,580	
Grant, Colo.		36.4	125	8,566	364.9
Cassells, Colo.		34.4	133	8,500	33.0
So. Platte, Colo. (gage)		0.3	484	6,091	70.6
Mouth	335.6	0	484	6,080	36.7

TABLE 4

River Mileages, Drainage Areas, Channel Elevations and Slopes (Cont.)

Location	Miles above mouth		Drainage area square miles	Elevations feet above mean sea level	Slope feet per mile
	Main Stream	Tributaries			
Plum Creek					
Source		43.1		8,500	
Castle Rock, Colo.		29.3		6,790	123.9
Sedalia, Colo.		9.5	273	5,723	53.9
Mouth	320.9	0	324	5,388	35.3
Bear Creek					
Source		44.0		12,740	
Near Brookvale		29.7		7,500	366.4
Morrison, Colo.		10.8	165	5,781	91.0
Mount Carbon damsite		8.2	236	5,520	100.3
Mouth	311.3	0	265	5,283	28.9
Little Dry Creek					
Source		15.1		6,000	
Little Dry Creek Dam		9.5	9.5	5,580	75.0
Englewood, Colo. (Clarkson Street)		2.5		5,325	36.4
Mouth	310.5	0	24.	5,265	24.0
Cherry Creek					
Source		68.0		7,630	
Near Table Rock		63.6		7,220	93.2
Near West Fork		46.9		6,585	38.0
Old Castlewood Damsite		40.7	168	6,370	34.7
Franktown, Colo. (gage)		39.0	172	6,148	130.6
Kenwood Dam		11.4	386	5,491	25.9
Mouth	302.8	0	414	5,168	28.3
Clear Creek					
Source		67.0		12,200	
Silver Plume, Colo.		52.9		8,500	262.4
Golden, Colo. (gage)		17.7	414	5,735	78.6
Below Golden		14.0		5,525	56.8
Mouth	296.0	0	600	5,110	29.6
St. Vrain Creek System:					
St. Vrain Creek					
Source		61.4		12,400	
Lyons, Colo. (gage)		33.4	266	5,349	251.8
Mouth	253.4	0	1,000	4,740	18.2
Boulder Creek					
Source		51.4		12,000	
Barker Reservoir		34.5		7,780	247.9
Near Boulder (gage)		27.3	137	5,500	316.7
Above Boulder, Colo.		20.0	143	5,280	30.1
Mouth	270.0	0	485	4,800	24.0
Coal Creek					
Source		30.7		8,887	
Near Coal Cr. Peak		20.5		6,000	283.0
Superior, Colo.		10.5		5,270	73.0
Erie, Colo		3.0	81.5	5,005	35.3
Mouth	277.5	0	83.6	4,955	16.7

TABLE 4

River Mileages, Drainage Areas, Channel Elevations and Slopes (Cont.)

Location	Miles above mouth		Drainage area square miles	Elevations feet a bove mean sea level	Slope feet per mile
	Main Stream	Tributaries			
Big Thompson River					
Source		79.0		11,000	
Near Estes Park		68.9	158	8,500	247.5
Near Prospect		52.5		7,000	91.5
Mouth of Canyon (gage)		40.1	308	5,400	129.0
Near Cedar Grove		37.1		5,095	101.7
Mouth	244.9	0	842	4,660	11.7
Cache la Poudre River					
Source		121.3		10,700	
Near Barnes-Meadow Reservoir		99.9		8,000	126.2
Near Ft. Collins National Park		56.1		5,225	63.4
Mouth of Canyon (gage)		49.9	1,048	5,070	25.0
Mouth	233.9	0	1,840	4,610	9.2
Crow Creek					
Source		120.0		8,600	
Above Cheyenne Reservoir		108.2		6,775	154.7
At Hecla, Wyoming		106.2		6,720	27.5
Silver Crown, Wyo.		99.9		6,400	50.8
Mouth	227.8	0	1,515	4,572	15.2
Kiowa Creek					
Source		114.5		7,500	
Near Elbert, Colo.		99.0		6,765	47.4
Near Sand Creek Reservoir		38.5		5,000	29.2
Mouth	203.0	0	760	4,380	16.1
Bijou Creek					
Source		116.4		7,200	
Near Kuhn's Crossing		99.0		6,000	69.0
Near Agate		88.9		5,000	99.0
Mouth	189.5	0	1,462	4,280	8.1
Beaver Creek					
Source		90.9		5,500	
Near Middlemist Reservoir		64.6		5,000	19.0
Mouth	170.4	0	1,301	4,130	13.5
Lodgepole Creek					
Source		215.8		8,500	
Near Cheyenne Pass		210.0		7,780	124.1
Near Islay		204.8		7,500	53.8
Near Islay		201.8		6,640	286.7
South Fork		169.3		5,725	28.2
Sidney, Nebraska		51.0		4,100	13.7
Mouth	98.4	0	3,101	3,500	11.8

Table 5 **Average Annual and Extreme Air Temperatures**
Degrees Fahrenheit

Station	Years of Record	Extreme Temperatures		Average Annual Temperatures			1949 Mean
		Max.	Min.	Maximum	Minimum	Mean	
Colorado							
Boulder	51	102	-33	63.1	38.1	50.6	50.7
Cheesman	44	99	-35	62.4	30.5	46.5	46.4
Denver	75	105	-29	63.0	37.8	50.4	50.0
Estes Park	31	98	-35	55.4	28.7	42.2	42.4
Ft. Collins	67	104	-38	61.6	33.1	47.0	47.0
Ft. Morgan	50	109	-36	63.2	32.5	47.9	48.0
Greeley	54	107	-45	64.2	31.9	48.1	48.2
Idaho Springs	48	93	-30	56.3	30.5	43.3	43.4
Julesburg	34	108	-38	64.6	34.3	49.5	49.6
Kassler	33	103	-32	66.4	36.5	51.5	51.5
Sedgwick	35	113	-40	64.8	33.6	49.3	49.3
Longs Peak	48	94	-41	50.5	24.6	37.5	---
Sterling	37	104	-33	63.7	33.1	48.4	14.87
Grand Lake	12	87	-41	---	---	36.4	16.21
Dillon	39	89	-46	50.9	15.2	34.3	19.01
Green Mtn. Dam	15	89	-40	---	---	40.2	13.95

Relative humidities are low in the plains region, the annual average at Denver being 42 to 63 per cent. Evaporation at Fort Collins, Colorado, shows an average monthly rate varying from 1.30 inches in December, to 6.23 inches in July.

Precipitation

The basin lies within the semi-arid plains region. The minimum average annual rainfall within the basin, excepting the South Park area, is 12.35 inches at Greeley, Colorado. The average annual rainfall at Hartsel in the South Park area is 11.10 inches. The maximum average rainfall occurs in the mountain regions, with 31.01 inches at Silver Lake, Colorado.

Table 6 presents the monthly distribution of precipitation in percentage of the average annual precipitation for representative weather stations in the South Platte River Basin and adjacent west slope diversion areas.

The snowfall in the South Platte River Basin is generally light except in the mountains. The greatest amount of snow falls during March in plains areas and during April in the mountains. Table 7 presents the minimum, maximum, and mean annual snowfalls at representative weather stations in the basin, and the greatest recorded depth of snowfall on the ground.

Table 6

Monthly Precipitation in Percentage of Average Annual Precipitation

Station	Elevation	Months												Average Annual Precipitation (Inches)
		J	F	M	A	M	J	J	A	S	O	N	D	
Wyoming														
Cheyenne	6,088	3	4	7	13	16	11	14	11	8	6	4	3	14.84
Nebraska														
Kimball	4,697	3	4	6	13	16	15	14	11	7	5	3	3	16.59
Colorado														
Ft. Collins	5,003	3	4	7	14	19	11	11	9	8	8	3	3	14.78
Greeley	4,658	2	3	6	13	19	12	14	9	8	8	3	3	12.35
Boulder	5,404	2	4	9	15	16	9	12	8	8	9	4	4	18.35
Denver	5,221	3	4	8	15	17	9	11	10	7	7	4	5	14.08
Sterling	3,939	2	2	5	13	17	15	11	12	9	7	3	4	14.87
Ft. Morgan	4,321	2	2	5	14	17	13	17	11	8	6	3	2	13.49
Sedgwick	3,583	2	2	5	13	15	16	15	13	8	6	2	3	17.14
Hartsel	8,860	2	3	4	7	8	10	25	20	10	5	3	3	11.10
Cheesman	6,890	2	3	6	13	12	9	18	15	9	6	3	4	15.51
Kassler	5,495	3	4	8	15	14	9	11	10	8	8	5	5	18.20
Idaho Springs	7,556	2	3	6	13	12	9	18	14	9	8	3	3	15.25
Silver Lake	10,200	6	9	11	13	9	8	12	7	7	6	6	6	31.01
Grand Lake*	8,380	10	13	7	12	7	6	11	9	6	6	5	8	16.21
Dillon*	8,900	7	9	11	11	9	6	11	9	7	7	6	7	19.01
Green Mtn.Dam*	7,760	6	7	10	13	10	9	8	9	6	9	7	6	13.95

* On western slope of the Continental Divide.

Table 7 Snowfall Data for South Platte River Basin

Station	Years of Record	Average Annual Snowfall (inches)			Greatest Depth of Snowfall on the Ground	
		Minimum	Maximum	Mean	inches	date
Colorado						
Boulder	51	36.5	122.2	68.7	24.7	12-19-1911
Cheesman	43	17.4	94.5	54.5	43.0	5 - 1913
Denver	61	17.9	115.9	55.7	32.6	12- 5-1913
Estes Park	36	41.8	193.0	102.0	48.0	12- 5-1913
Ft. Collins	69	6.1	67.8	39.3	26.0	2- 2-1883
Ft. Morgan	50	7.3	49.9	25.8	18.0	2-29-1912
Greeley	54	4.9	76.2	31.0	26.0	4-19-1920
Idaho Springs	45	36.5	132.3	70.3	51.0	12- 5-1913
Julesburg	38	6.9	63.3	28.3	13.0	1- 4-1949
Kassler	42	16.0	102.4	67.6	55.0	12- 8-1913
Longs Peak*	51	65.7	274.6	147.6	36.0	10-25-1923
Sedgwick	40	4.7	73.3	29.2	12.0	3-11-1912**
Sterling	37	7.0	58.0	32.6	13.0	12-14-1940
Grand Lake	10	77.5	179.3	121.5	39.0	4- 6-1920
Dillon	37	65.8	205.5	121.4	40.0	2-27-1918

* Currently inactive.
** Also occurred January 31, 1949.

Snow surveys have been made for the past ten years at sixteen snow courses in the South Platte River Basin by the U. S. Department of Agriculture and the Colorado Agricultural Experimental Station, Ft. Collins, Colorado, in cooperation with other federal, state, and local agencies. All of these snow courses are above elevation 8,600 feet and eleven are above elevation 10,000 feet. The ten-year average snow depth and water content on the ground on April 1st in the major watersheds in the basin were computed from the results of those surveys and are presented in Table 8.

Table 8 Average Snow Depth and Water Content on April 1

Watershed	Average Snow Depth inches	Average Water Content inches
South Platte River above Denver	22.3	5.9
Crow Creek	16.0	4.5
Cache la Poudre River	40.9	12.6
St. Vrain Creek	44.4	13.2
Boulder Creek	39.6	11.2
Clear Creek	49.6	14.8

Runoff

A summary of published stream flow data is presented in Table 9. Table 10 lists stream gaging stations in operation in the basin. Detailed considerations of stream flow as related to water pollution problems are contained in following sections of this report.

Table 9 Summary of Published Stream Flow Data for the South Platte River and Tributaries

Stream	Station	Mileage	Drainage Area sq.mi.	Maximum Peak Discharge		Minimum Mean Daily Discharge second-feet	Annual Runoff		
				sec.-ft.	date		maximum acre-feet	minimum acre-feet	mean acre-feet
South Platte River	Near L. George	384.0	929	990	8-15-30	8.0	108,000	10,270	62,630
	Lake Cheesman	361.5	1,730	3,030	4-23-42	6.5	242,300	35,300	126,940
	Waterton	327.4	2,611	5,700	4-23-42	0.1	513,900	41,530	134,010
	Denver	302.3	3,840	22,000	9-10-33	15.0	801,600	103,900	266,600
	Henderson	286.7	4,792	10,700	4-26-42	6.0	844,000	115,300	242,970
	Ft. Lupton	272.2	5,108	9,000	4-26-42	10.0	877,500	113,100	251,380
	Kersey	231.9	9,500	31,000	6- 7-21	35.0	1,435,000	181,470	560,650
	Sublette	210.0	12,269	30,000*	6- 7-21	--	420,200	93,840	231,060
	Balzac	164.1	17,194	**	5-31-35	4.6	1,030,000	69,000	278,260
	Julesburg	90.2	22,800	31,300	6- 2-35	0.0	1,092,000	61,790	323,700
	N.Platte, Nebr.	0.0	24,030	37,100	6- 3-35	0.0	1,055,000	56,360	377,530
Bear Creek	Morrison, Colo.	11.5	165	8,600	7-24-96	0.8	90,560	13,640	43,580
	Mouth	0.75	265	3,000	7- 7-33	0.7	98,490	5,440	27,820
Clear Creek	Golden, Colo.	18.0	414	8,700	8- 1-88	18.0	278,800	109,900	176,260
	Mouth	0.8	600	3,650	9- 3-38	0.9	118,450	20,900	60,770
St. Vrain Cr.	Lyons, Colo.	36.6	266	10,500	6-22-41	0.0	145,200	51,500	96,490
	Mouth	2.7	1,000	11,300	9- 3-38	12.0	343,770	40,000	130,310
Boulder Cr.	Orodell, Colo.	27.7	105	2,500	6- 6-21	1.5	100,700	37,300	67,700
	Mouth	0.0	485	4,410	9- 3-38	0.0	149,420	3,230	40,420
Big Thompson River	Cañon mouth near Drake	39.7	308	5,600	9- 1-38	7.0	150,230	83,350	128,750
	Mouth	0.2	842	3,000	9- 3-38	0.0	48,440	12,560	34,890
Cache la Poudre River	Cañon mouth	59.4	1,048	**	5-20-04	3.0	381,400	135,200	303,450
	Mouth	1.1	1,840	4,240	6-24-17	2.3	100,400	20,270	68,300

* Approximate ** Not determined

Table 10

Stream Gaging Stations in Operation
South Platte Basin
As of 1949

Stream and Station	Drainage Area a/	Record Began
South Platte above Elevenmile Reservoir	861	1939
South Platte near Lake George	929	1929
South Platte above Lake Cheesman	1,680	1924
South Platte below Lake Cheesman	1,766	1924
South Platte at South Platte below North Fork	2,550	1902
South Platte at Waterton	2,621	1926
South Platte at Littleton	3,090	1941
South Platte at Denver b/	3,840	1895
South Platte at Henderson	4,740	1926
South Platte at Ft. Lupton	5,070	1906
South Platte at Kersey	9,500	1901
South Platte at Sublette	12,900	1926
South Platte at Ft. Morgan	14,800	1943
South Platte at Balzac	17,700	1914
South Platte at Julesburg	22,800	1902
South Platte at Ogallala, Nebraska	23,500	1931
South Platte at Paxton, Nebraska	23,700	1939
South Platte at North Platte, Nebraska	24,300	1914
Tarryall Creek near Lake George (near mouth)	460	1910
Goose Creek above Lake Cheesman	86	1909
North Fork of South Platte at Grant below Geneva Creek	130	1942
North Fork of South Platte at Pine	374	1942
North Fork of South Platte at South Platte	484	1909
Deer Creek near Littleton	22	1942
Plum Creek near Sedalia	273	1942
Turkey Creek near Morrison	49	1942
Bear Creek at Morrison	165	1888
Bear Creek at mouth	265	1914
West Fork of Clear Creek above Empire	40	1929
Clear Creek below Lawson	...	1946
Clear Creek near Golden	392	1908
Clear Creek at mouth near Derby	600	1914
Cherry Creek near Franktown	172	1939
Cherry Creek near Melvin	369	1939
Cherry Creek at Denver	420	1942
South Boulder Creek near Eldorado Springs	114	1888
Boulder Creek near Orodell	105	1887
Fourmile Creek near Boulder c/	...	....
Boulder Creek at mouth near Longmont	512	1927
St. Vrain Creek at Lyons	226	1887
Lefthand Creek near Boulder d/	48	1929
St. Vrain Creek at mouth near Platteville	1,000	1915
Little Thompson above irrigation (above Ish Ditch) c/	...	....
Glacier Creek above Estes Park c/	...	....
Fall River above Estes Park c/	...	....

Table 10 (Cont'd)

Stream and Station	Drainage Area a/	Record Began
Big Thompson at Estes Park	158	1930
Fish Creek near Estes Park c/	...	....
North Fork of Thompson below Estes c/	...	....
Big Thompson below power house near Drake	277	1928
Big Thompson at canyon mouth near Drake	302	1917
Cottonwood Creek near Drake c/	...	....
Buckhorn Creek near Masonville c/	...	....
Big Thompson at mouth near LaSalle	818	1914
Cache la Poudre at canyon mouth	1,048	1881
Cache la Poudre near mouth near Greeley	1,840	1903
North Fork of Crow Creek near Hecla, Wyoming	27	1933
Middle Fork of Crow Creek near Hecla, Wyoming	23	1933
South Fork of Crow Creek near Hecla, Wyoming	16	1933
Boxelder Creek near Hudson, Colorado	...	1942
Lodgepole Creek at Bushnell, Nebraska	1,090	1931

a/ Drainage areas are in square miles.
b/ Records continuous since May 7, 1895.
c/ Installed in late 1947. No data available at this date.
d/ Re-installed in late 1947. No further data available at this date.

ECONOMIC DEVELOPMENT

Population

The total population in the basin in 1940 was 665,644, of which 602,074 or 90% were in Colorado; 31,149 were in Nebraska; and 32,421 were in Wyoming. Of the total basin population in 1940, 67% was urban and 33% was rural living on farms or in towns of 2,500 or less. The density of population in the basin, excluding Denver, North Platte, and Cheyenne, is 14.8 persons per square mile in Colorado, 8.6 per square mile in Nebraska, and 5.0 per square mile in Wyoming. Table 11 shows the population growth of cities in the South Platte Basin for the period 1900 to 1949. Table 12 shows the comparative growth of urban, rural, and farm populations in the basin for the period from 1900 to 1940. In 1949 the total estimated population for the entire basin was 754,000.

Table 11 **Populations of Cities in the South Platte River Basin from 1900 - 1949**

Location	Census Year					
	Est. 1949	1940	1930	1920	1910	1900
Colorado						
Boulder	16,000	12,958	11,223	11,006	9,539	6,150
Brighton	--	4,029	3,394	2,715	850	366
Brush	--	2,481	2,312	2,103	997	381
Denver	405,000	322,412	287,861	256,491	213,381	133,859
Englewood	--	9,680	7,980	4,356	2,983	--
Ft. Collins	20,000	12,251	11,489	8,755	8,210	3,053
Ft. Morgan	--	4,884	4,423	3,818	2,800	634
Golden	--	3,175	2,426	2,135	2,477	2,152
Greeley	20,000	15,995	12,203	10,958	8,179	3,023
Julesburg	--	1,619	1,467	1,320	962	371
Littleton	--	2,244	2,019	1,626	1,373	738
Longmont	--	7,406	6,029	5,848	4,256	2,201
Loveland	--	6,145	5,506	5,065	3,651	1,091
Sterling	9,500	7,411	7,195	6,415	3,044	998
Nebraska						
Kimball	--	1,725	1,711	1,620	454	254
North Platte	17,600	12,428	12,061	10,466	4,793	3,640
Ogallala	--	3,159	1,631	1,062	643	355
Sidney	--	3,388	3,306	2,852	1,185	1,001
Wyoming						
Cheyenne	35,500	22,474	17,361	13,829	11,320	14,087

Table 12

Comparative Growth of Urban, Rural and Farm Populations in the South Platte River Basin 1900 - 1940

Year	Urban		Rural		Total	
	Number	Percent Increase	Number	Percent Increase	Number	Percent Increase
1900	167,608	--	95,279	--	262,887	--
1910	269,755	60.9	137,550	44.4	407,305	54.9
1920	337,341	25.1	172,034	25.1	509,375	25.1
1925	--	--	--	--	--	--
1930	384,000	13.8	201,887	17.4	585,887	15.0
1940	445,018	15.9	220,626	9.3	665,644	13.6

Agricultural Development

Agriculture, including the raising of livestock, long has been a primary activity in the basin. The principal crops grown in the South Platte River Basin in the order of value are hay and forage, wheat, sugar beets, potatoes, barley, dry beans, corn, oats, rye, sorghums and other grains, and seed. The Nebraska portion of the basin normally produces nearly half of the wheat in the basin and about one-third of the corn. Of the other crops mentioned, the Nebraska and Wyoming portions of the basin produce percentages roughly corresponding to the proportional areas of those states in the basin. The mean total value of the principal crops produced in the Colorado portion of the basin between 1930 and 1940 was $33,050,000. Increase in value of farm products during World War II is reflected in the receipts of $67,562,000 for the same crops in 1944, as determined from the last available agricultural census. Truck farming has shown a decided upward trend, both in values and acreage, corresponding roughly to the population trend of the City of Denver. Most of the truck farming in the basin is carried on in the vicinity of Denver and in the northern Colorado area - value of small fruits and vegetables produced in the basin in 1944 was $4,491,500 Shipments of truck produce to areas outside of the basin are increasing from year to year. Current shipments exceed 4,000 cars per year from the Denver area. Table 13 presents the values of crops produced in the South Platte River Basin in 1939 and in 1944 and shows the approximate distribution of those crops in the different parts of the basin.

Table 13

Values of Principal Crops Produced in South Platte Basin

Crop	Year	Basin Total	Colorado	Nebraska	Wyoming
Hay & Forage	1939	$ 6,590,800	$ 6,081,700	$ 428,300	$ 80,800
	1944	$12,991,800	$12,007,400	$ 597,500	$386,900
Wheat	1939	6,525,000	3,885,300	2,606,300	33,400
	1944	12,392,900	6,684,300	5,512,200	196,400
Sugar Beets	1939	5,807,200	5,627,400	177,400	2,400
	1944	12,345,100	12,109,800	190,900	44,400
Potatoes	1939	2,818,800	2,533,000	254,800	31,000
	1944	8,746,400	8,185,200	400,600	160,600
Barley	1939	2,447,800	2,292,800	152,600	2,400
	1944	7,086,400	6,548,100	447,500	90,800
Beans (dry)	1939	2,227,800	2,218,800	9,000	0
	1944	5,201,500	5,120,500	58,200	22,300
Corn	1939	1,292,900	775,000	492,100	25,800
	1944	6,177,800	5,129,600	862,600	185,600
Oats	1939	425,200	359,300	62,700	3,200
	1944	2,057,200	1,674,500	249,900	132,800
Rye	1939	112,300	52,900	56,500	2,900
	1944	171,200	112,200	45,900	13,100
Sorghum (grain)	1939	33,500	14,000	19,400	100
	1944	346,600	328,200	18,200	200
Mixed Grains	1939	26,800	14,400	12,400	0
	1944	45,100	27,500	16,300	1,300
Totals	1939	$28,308,100	$23,854,600	$4,271,500	$ 182,000
	1944	$67,562,000	$57,927,300	$8,399,800	$1,234,900

Irrigated and Non-Irrigated Crops

The South Platte River Basin lies in a semi-arid region and depends largely on irrigation for its agricultural wealth. Although a considerable portion of the arable land is devoted to dry farming, the greater percentage of the production is from irrigated land. The value of irrigation is strikingly shown in Table 14, which presents a comparison of yields per acre for various crops on irrigated and dry farms in Colorado and Nebraska.

Table 14

Comparison of Yields Per Acre on Irrigated and Non-Irrigated Land

Crop	Unit	Colorado		Nebraska		Entire Basin	
		Irrigated	Dry	Irrigated	Dry	Irrigated	Dry
Corn	Bu	26.6	5.5	28.6	8.9	26.9	7.7
Oats	Bu	33.1	10.8	29.2	15.2	32.9	13.1
Barley	Bu	34.4	6.8	33.7	13.0	34.4	8.8
Rye	Bu	17.7	6.1	15.3	10.4	17.5	8.9
Wheat	Bu	22.8	8.9	15.9	12.8	22.8	10.8
Sorghums (grain)	Bu	10.3	5.4	15.3	8.4	10.8	6.8
Beans	Bu	20.9	2.5	12.1	3.3	20.9	2.5
Potatoes	Bu	205.3	22.2	169.8	35.8	201.0	34.5
Sorghums (forage)	Tons	1.6	0.5	1.3	1.1	1.6	0.7
Alfalfa	Tons	2.0	1.1	2.2	1.4	2.0	1.2
Other:							
Tame Hay	Tons	1.1	0.7	0.7	0.9	1.0	0.7
Wild Hay	Tons	0.7	0.7	0.9	0.7	0.7	0.7

Wyoming yields are omitted from this table because of the small acreages involved, and truck crops are omitted because they cannot be raised on non-irrigated lands in this region. The total basin acreage under irrigation in 1939 (1940 census) was about 1,200,000 acres, 96% of which was located in Colorado, and 3% of which was located in Nebraska. Since the acreage under irrigation is a function of the total annual water supply, there has been no marked increase in irrigated acreage in the basin since the early part of the present century because all of the available surface water had been appropriated by that time. Increase in the amount of irrigated lands since that time has been dependent upon the development of ground water sources. It is anticipated that the completion of the Colorado-Big Thompson Project by the Bureau of Reclamation will not bring about any increase in the irrigated acreage in the area served. This project will serve to supply additional water for increased irrigation of the approximate 615,000 acres already under ditches and will provide protection to crops during dry years when insufficient moisture is available for maximum crop production. Indirect benefits will probably result from the increase i direct return flows to the streams and from possible incidental recharge of ground water resulting from the increase in seepage through the application of more water to the soil. The proposed Blue-South Platte Project, on the other hand, contemplates the placing of about 112,000 acres of new lands under irrigation. These new lands will be irrigated either by surface waters supplied directly from ditches, or by ground waters resulting from recharge attributable to project operations.

Livestock

The livestock industry is one of the oldest in the basin, ranking second in age only to mining. Settlement and fencing of the range lands have brought about a general decrease in livestock raising in the past several decades, but it is still a major industry, furnishing the raw product for many large factories and packing plants in the area. The livestock raised in the basin includes beef and dairy cattle, sheep, swine, horses, mules, goats, and poultry. Cattle have consistently ranked first in value among domestic animals. The total value of all livestock in the basin in 1944 was $49,841,000.

The dairying industry ranks as one of the more important in the basin and includes butter and cheese manufactured on the farm and in factories, whole and evaporated milk, ice cream and similar products. Total value of dairy products sold in 1944 was $10,070,700. Poultry, including chickens, turkeys, ducks, and geese, is raised on the farm and in a large number of establishments engaged in the business on a considerable scale. Honey produced in the basin commands top prices on eastern markets.

Industrial Development

The industrial development of the South Platte River Basin, although highly diversified, is not on a large scale; the rural districts are devoted more to agricultural pursuits, and the larger centers to educational and resort purposes. The manufacturing center of the South Platte River Basin, and for a large portion of the Rocky Mountain Region as well, is in, and immediately adjacent to, the City of Denver. A great impetus was given to manufacturing in this area during the advent of World War II, as well as by increasing freight costs on shipments of manufactured items from other areas. Current estimates of the value of manufactured goods produced in the basin would indicate that manufacturing is rapidly becoming the foremost source of income for the region, displacing agriculture which has held this honor in the past.

Industrial establishments closely allied with agriculture are located in and near farm centers throughout the agricultural region. These establishments include beet sugar factories, canneries for fruits, vegetables, and milk, meat packing, poultry dressing, baking, and mills for processing flour and other grains. Miscellaneous industries found in the basin include ceramics, explosives, and timber products manufacturing.

Mining - The mining industry ranks third in the South Platte River Basin. In recent years, coal has replaced metals in production value, metals mining having decreased greatly since the end of the war. In 1935, the aggregate value of gold, silver, copper, lead, and zinc mined in the basin was $5,124,200. This had decreased to $1,250,000 in 1949. Gold produced in 1940 was valued at $4,203,000 which represented nearly 90% of that year's total. Production of gold reached a peak in 1900, after which it declined until 1929. Coal is the principal non-metal produced in the basin. In 1947, a total of 1,678,223 tons of sub-bituminous coal were mined. There has been a decrease in the amount of coal produced in recent years due, among other things, to the availability of a cheap natural gas supply to the region; to the conversion to other fuels by the railroads and other large consumers; and to increased production and transportation costs which make the use of competitive fuels more attractive. Other non-metals produced in the basin are gypsum, clay, lime, building stone, sand, gravel, mica, and cement.

Petroleum production within the basin reached a peak of 1,230,100 barrels with an estimated value of $2,900,000 in 1926. The output has diminished greatly since that time however, the production in 1940 being only 161,000 barrels. With the installation of a pipeline from the Lance Creek Field in Wyoming to the vicinity of Denver in 1938, petroleum refining has become an important industry in the basin. Natural gas occurs in the basin near Ft. Collins and Berthoud, Colorado. The only production at present is from the Berthoud field and is used for the manufacture of gasoline. There has been increased activity in the petroleum field during the past few years, particularly in location and prospecting operations.

Lumber produced in 1940 in the South Platte River Basin was valued at $46,500. The products consisted chiefly of rough timbers and telegraph and telephone poles.

Transportation Facilities in the Basin

Railroads

The South Platte River Basin is served by five major railroads; the Union Pacific; the Chicago, Burlington and Quincy; the Denver and Rio Grande Western; the Colorado and Southern; and the Atchison, Topeka, and Santa Fe. The main line mileage within the basin is 1,471 miles, of which 366 miles are double tracked. In addition, the Great Western Sugar Company operated a standard gage rail system, 85 miles in length, during the beet harvesting season to facilitate deliveries to its factories. Completion of the Moffat Tunnel in 1928 shortened the distance to the Pacific Coast by 176 miles and greatly improved transportation facilities serving Denver and the central and southern parts of the basin.

Highways

The basin area is served by an extensive highway system, including transcontinental U. S. highways, state highways, and secondary "farm to market" roads. The total mileage of all types, excluding city streets, is 27,744 miles, 3,000 miles of which are included in the federal and state highway systems.

Airways

Denver is one of the key administration centers for airways and serves as an airways communication and traffic control center for the general western territory. The United, Western, Continental, Braniff, Challenger, and Monarch Airlines provide passenger, freight, and mail service, both transcontinental and local.

Waterways

There are no waterways suitable for commercial navigation within the South Platte River Basin.

Land Ownership in the Basin

There are approximately 4,900 square miles of public land within the South Platte River Basin, including national forests and parks, military reservations, public domain, state lands, and municipal parks. The national forests were created primarily for the production of timber and for the protection of watersheds. The Pike, Arapahoe, Roosevelt, Medicine Bow, and Cochetopa National Forests are all or partly included in the basin; a total area of about 2,700 square miles. About 260 square miles of the Rocky Mountain National Park area are included within the basin. Government reservations are scattered throughout the basin, including Lowry Field, Buckley Field, Fitzsimons General Hospital, and the Rocky Mountain Arsenal near Denver; Fort Francis E. Warren near Cheyenne; and Sioux Ordnance Depot near Sidney, Nebraska. The total area of these military reservations is about 180 square miles.

Table 15 presents a summary of the land ownerships within the basin area and the percentage of the basin in each classification.

Table 15 **Land Ownership in South Platte River Basin**

Ownership	Area Sq. Mi.		Percent of Basin	
Federal Government:				
National forests and parks	3,031		13	
Military reservations	181		1	
Public domain	320		1	
Subtotal		3,535		15
State lands	1,377		6	
Municipal mountain parks	35		--	
Private	17,423		73	
Unclassified (Water area and miscellaneous	1,660		6	
Subtotal		20,495		85
TOTAL		24,030		100

REVIEW OF WATER POLLUTION CONTROL LAWS

In accord with Par. 2, item (b) of the "Memorandum of Understanding" (Appendix "A"), the following review of the water pollution laws of Colorado, Nebraska, and Wyoming, is presented. A Suggested State Water Pollution Control Act and an Explanatory Statement may be found in Appendix "E" of this report. The following information is based largely upon review memoranda prepared by the Office of the General Counsel, Federal Security Agency, and upon a similar discussion presented in the report on the Kansas River Basin Water Pollution Investigation.* This material appeared in the interim South Platte River Water Pollution Investigation Report (April, 1949) and has been reviewed by the States involved.

State of Colorado

Summary

The State Department of Public Health has been designated as the water pollution control agency for Colorado for purposes of the Federal Government's Public Law 845 (80th Congress). Responsibility for water pollution control in the State is shared, however, with other public authorities, e.g., State Game and Fish Department. The health department's powers are limited to the public health aspects of water pollution control. More detailed and broader statutory authority would be desirable and this authority, when provided, should be centered in a single State agency such as the State Department of Public Health. Colorado cities have adequate sewage works financing laws. Sanitary districts can be formed. The State Health Department has been active in the field of water pollution control but lack of personnel and funds have tended to limit the intensity and scope of this program.

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* Federal Security Agency,
Public Health Service, June, 1949.

Administrative Authority

Chapter 208 of the 1947 Session Laws of Colorado gives considerable responsibility in the field of water pollution control to the State Department of Public Health. No specific statutory provision is made for the administrative establishment of a water pollution control authority. However, in Section 5, par. 7, of the Act cited as "The Department of Health Reorganization Act of 1947," the Department of Public Health is given the power and duty:

> "to establish and enforce minimum general sanitary standards as to the quality of water supplied to the public and as to the quality of the effluent of sewerage systems and trade wastes discharged upon the land or into the surface or ground waters . . . and to advise with municipalities, utilities, institutions, organizations and individuals, concerning the methods or processes believed to be best suited to provide the protection or purification of water and the treatment of sewage and trade wastes to meet such minimum general sanitary standards." (See next section for definitions).

In order to meet the foregoing and other allied statutory duties, the Department of Public Health has, in fact, established an Environmental Sanitation Division.

Definitions

The only definitions found in the Reorganization Act are in Section 5, par. 21, where the terms "minimum general sanitary standards" and "standards" are defined as follows: "The phrase 'Minimum general sanitary standards' as used in this section shall mean the minimum reasonably consistent with protection of the public health. The word 'standards' as used in this section shall mean standards reasonably designed to promote and protect the public health." The term "trade wastes" used in Section 5, par. 7, is not defined, and a definition is needed. It should be made clear whether "trade wastes" include all mining wastes. Definitions of other terms should also be supplied. (See Appendix "E").

Comprehensive Program; Co-operation

There is no specific statutory authorization for a comprehensive water pollution control program, although such would be desirable.

Specific authority should be granted to the Department of Public Health for co-operation with other States and with the Federal Government in matters of water pollution control. The State Health Authority has general statutory authorization for co-operation with the Federal Government and has and is now co-operating with the Public Health Service in water pollution investigations.

Stream Standards; Classification

The Reorganization Act of 1947 gives the State Department of Public Health the statutory power and duty to set "minimum sanitation standards" of water purity. This may prove difficult, and the setting of such rigid standards might act as a detriment to adequate water pollution control in the future. It is also well to note that the minimum standards by definition can apply only to the protection of the Public Health and thereby limit the activities of the Health Department in its capacity as the State Water Pollution Control Agency.

Permits

There are no statutory requirements for permits covering the installation of sewerage works. However, the rules of the Health Department require application to and approval of the Health Department prior to construction of new sewerage works or the alteration of existing works. Statutory authority should be provided to require permits for:

(1) the construction, installation, modification or operation of any disposal system or part thereof or any extension or addition thereto;

(2) the increase in volume or strength of any wastes in excess of the permissive discharges specified under any existing permit;

(3) The construction, installation, or operation of any industrial or commercial establishment or any extension or modification thereof or addition thereto, the operation of which would cause an increase in the discharge of wastes into the waters of the State or would otherwise alter the physical, chemical or biological properties of any waters of the State in any manner not already lawfully authorized;

(4) the construction or use of any new outlet for the discharge of any wastes into the waters of the State.

Orders for Pollution Abatement

In that the State Health Department, by statute, can issue orders only on matters relating to public health, a serious deficiency exists as far as water pollution control is concerned. This defect should be corrected by statute.

Plans and Specifications

Submission of plans and specifications for all types of sewerage works, including additions or alterations, is required by the rules and regulations of the State Health Department. These rules apply to municipalities, districts, corporations, companies, institutions and persons where the population served is in excess of 25. Separate industrial waste treatment plants should be included. It is desirable to include the requirement for submission of plans and specifications in the State statutes.

Federal Water Pollution Control Act (Public Law 845 - 80th Cong.)

There is no specific authority for State co-operation with the Federal Government in connection with this Act. General authority for co-operation with the Federal Government is provided by the Reorganization Act of 1947 under which the State Health Authority may accept, use, disburse, and administer all Federal aid or other property, services, and funds allotted to it for State or local public works or public health functions. The Department may enter into agreements as may be required prior to receiving such funds, provided, these agreements are not inconsistent with Colorado law and are approved by the State Attorney General.

Division of Authority

The State Health Department shares the responsibility for water pollution investigations and control with the State Game and Fish Department and with the City and County of Denver. The Game and Fish Department is responsible for the control of mine tailings pollution, and the City of Denver, by statute, is given control over "The South Platte River, Bear Creek, and any of their tributaries above the mouth of Clear Creek," which essentially covers the Denver public water supply catchment area. (Sec. 257, et seq., Ch. 48, Colorado Statute Annotated, 1935).

Inasmuch as the State Health Authority already has been granted considerable authority in water pollution control matters, the powers of this agency should be broadened to cover all types of water pollution throughout the State and thus center all water pollution control work in one State agency if it is not decided to create an independent water pollution control agency. (See Appendix "E").

Sanitary Districts

There is statutory authority for the formation of sanitary districts in Colorado.

Financing of Pollution Abatement Works

In general Colorado cities have adequate authority for issuance of revenue or general obligation bonds for the financing of sewerage works. It appears there is no legal authority allowing State-owned institutions to join with municipalities in the financing, construction, and operation of treatment plants.

Water Pollution Control Program

While the State Health Department has been active in this field, cities and most industries still discharge untreated or inadequately treated wastes into the waters of the State. Surface water resources are limited, and the extensive use of these waters for irrigation is a further complication. Critical stream pollution problems exist. There has been a considerable turnover in key sanitary engineering personnel in recent years. This, coupled with insufficient funds and personnel, has limited the scope and extent of the program in the past. Recently an advisory board has been formed to meet with and advise the Health Authority with regard to water pollution control. This advisory board is made up of representatives of public and private agencies, including industry, concerned with water pollution control. Its main function is to assist the Health Authority in the formulation of rules and regulations including "minimum sanitary standards" and to assist the Health Authority in formulating a comprehensive water pollution control program within the statutory limitations. The development of a definite program together with trained personnel and adequate funds should improve the situation greatly.

Of the total Colorado population served by sewer systems, about 86 per cent are served by some type of sewage treatment plant. This large percentage of the population, however, only represents 49 per cent of the total number of sewered communities. While the total population served by sewer systems compares favorably with the national average of about 63 per cent, the per cent of sewered cities providing treatment plants is much less than the national average of about 61 per cent. These figures indicate that the bulk of pollution abatement promotion is needed in the smaller cities in Colorado.

State of Nebraska

Summary

Existing State water pollution laws are inadequate for present needs. Nebraska should enact comprehensive water pollution control legislation based upon the principles presented in Appendix "E". The powers of the State Health Department should not be limited to the public health aspects of water pollution but should apply to all pollution detrimental to water use. There should be no division of authority. Enabling legislation for cities appears adequate and sanitary districts can be formed. The State's water pollution control program has accomplished considerable improvement but much remains to be done. Serious handicaps to the program have been lack of personnel and inadequate laws. Both of these deficiencies should be corrected.

Administrative Authority

There is no comprehensive water pollution control law and no statutory requirement for the development of a broad water pollution control program or for the administrative enforcement thereof. Legislation based upon the principles presented in the Suggested Act (see Appendix "E") should be enacted as soon as possible. The only statutory authority for water pollution control is given in section 81-602, Revised Statutes of Nebraska, which states:

> "The Department of Health shall have general supervision and control over matters relating to public health and sanitation ..."

This statute authorizes the Department of Health to adopt reasonable rules and regulations as will best serve to promote sanitation throughout the State.

The State Health Department has been designated as the Water Pollution Control Agency for the State for the purposes of the National Water Pollution Control Act.

Definitions

Section 37-516, Revised Statutes of 1943, defines "refuse" as all substances harmful to aquatic life and forbids its discharge into any waters of the State. This statute exempts corporations, villages and cities of the second class discharging sewage or refuse prior to August 21, 1931, and is of little value to a general water pollution control program.

Definitions of "pollution," "wastes," etc., should be included in any comprehensive water pollution legislation adopted by Nebraska.

Comprehensive Program; Co-operation

The powers and duties of the State Health Department appear to be quite limited as far as water pollution is concerned. The functions of the Sanitation Division of the Health Department are principally advisory and educational.

The State Health Department co-operates with various State and Federal agencies in connection with water pollution control problems, even though it is not specifically authorized by statute to do so. Such co-operation should be specifically authorized by law.

Investigations

Water pollution investigations are conducted under the very general authority granted to the State Health Department by the statutes. More specific authority is needed (Appendix "E").

Stream Standards; Classification

There is no specific authority for the classification of waters according to use or for the adoption of stream standards. Specific legislation is needed (Appendix "E").

Rules and Regulations

General authority for the adoption of rules and regulations is given the Health Department under section 81-602 but specific authority in the field of water pollution control is needed (Appendix "E").

Permits

No permit system is in operation. A permit system is administratively desirable and should be considered for inclusion in any future water pollution control legislation (Appendix "E").

Orders for Pollution Abatement

No specific authority is provided by statute. Presumably the State Health Department could act if there were a serious public health hazard. Specific authority is needed but it should not be limited to public health problems alone; pollution detrimental to all other water uses should be included as well.

Plans and Specifications

Plans for systems serving more than 25 persons are required by Health Department rules and regulations to be submitted for approval. Industrial waste treatment plants are not included.

Federal Water Pollution Control Act (Public Law 845 - 80th Cong.)

There is no specific statutory authority for co-operating with the Federal Government in connection with this Act.

Division of Authority

Some division of authority and responsibility exists between the State Fish and Game Agency and the State Health Department. The Fish and Game Agency may take action through county attorneys to secure abatement of pollution harmful to aquatic life. A single State agency should be designated to handle all types of water pollution problems and such provision should be included in any comprehensive water pollution control legislation considered for enaction by the State (See Appendix "E").

Enforcement

Enforcement provisions for water pollution control appear to be deficient and should be strengthened in any future legislation which may be adopted. Penalties are provided for failure to comply with rules and regulations of the Health Department and vary from $15 to $100 for each offense.

Sanitary Districts

Section 31-701, et seq., Revised Statutes, Supplement 1947, indicates that sanitation districts may be formed (certain areas may not be included in such districts), and that such districts may provide for the construction and maintenance of necessary sewage works.

Financing of Pollution Abatement Works

All villages and cities may issue "mortgage bonds (section 18-502). These bonds are not a general obligation of the municipality and are secured by the property, e.g., the sewage works, and any revenues derived therefrom. This method of financing is quite valuable to municipalities in financing sewage treatment works.

Sanitation districts (section 31-701) may issue general obligation bonds up to 10 per cent of the assessed valuation of taxable property to finance sewerage works. In the event "mortgage bonds" are used to finance the project, the 10 per cent limitation does not apply.

All cities and villages are authorized under section 18-502, et seq., to own, construct, equip and operate sewage works within or outside the city or village. They may condemn needed lands, levy taxes,* and issue bonds (including mortgage bonds) in accordance with statutory provisions. They may adopt rules and regulations governing the use of sewers and treatment plants and prescribe charges for use of same. If charges are not paid, the city or village may recover by appropriate statutory action against the defaulter.

Water Pollution Control Program

Nebraska has a fairly good record in water pollution control and the State Health Department enjoys the confidence of State and city officials and of the public at large. However, there is a definite need for adequate statutory backing. There is also a need for additional trained personnel on the Health Department staff to aid the present experienced and competent engineers in their work throughout the State. Sufficient funds should be provided for this purpose.

Less than half of the sewered population in the State is served by treatment plants, as against the national average of 63 per cent. About 56 per cent of the communities with sewer systems provide treatment, in contrast with the national average of about 61 per cent.

State of Wyoming

Summary

The State Board of Health has been designated as the water pollution control agency for the State. However, there is some division of authority and responsibility with the Game and Fish Commission in matters of water pollution control. The State Board of Health has power over water pollution as it affects public health** and there are no statutory provisions for exemption from its jurisdiction. General statutes relating to water pollution and control are contained in Articles 1 and 2, Ch.63, Wyoming Compiled Statutes, as amended. Review and approval of plans and specifications by the Board of Health is provided by statute. There is no statutory mandate for the setting of standards or for the classifying of streams. Lack of personnel and inadequate funds have hampered efforts on water pollution control.

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* Legislative Bill 417, approved May 17, 1951, increased the allowable tax levy from one-half to one mill.

** Senate Bill No. 30, enacted by Wyoming Legislature February 9, 1951, provides that any pollution which adversely affects livestock, agricultural crops, wildlife, fish or aquatic life, is also deemed to affect public health.

Administrative Authority

The Department of Public Health consists of two divisions: the State Board of Health and the Division of Administration (section 63-144). Specific and direct authority over water pollution control rests in the Division of Administration (section 63-147 (1)). The Board has authority to determine general policies to be followed by the Division of Administration in administering public health laws (section 63-147 (2)).

Water pollution control activities are centered in a Division of Environmental Sanitation.

The Department of Public Health has State-wide jurisdiction in the area of water pollution control.

Definitions

Definition of the terms "wastes," "pollution," etc., should be included in any comprehensive water pollution control legislation which may be considered in the future (see Appendix "E").

Comprehensive Program; Co-operation

A council appointed by the Governor, consisting of the Director of the State Department of Public Health, State Game and Fish Commissioner, State Engineer, State Commissioner of Agriculture, and five other members, one of whom a representative of industry and one a representative of municipal government, is charged with the primary duty of advising the State Department of Public Health in developing a comprehensive program for the prevention, control and abatement of new or existing pollution of the waters of the State (section 63-201).

The State Board of Health is to co-ordinate the activities of the agencies of the State concerned with water quality (section 63-201).

There are no specific statutory provisions authorizing co-operation with other States or the Federal Government in the matter of pollution control. The State, however, does co-operate freely in such matters with the Federal Government and with other State agencies.

Investigations

The Department of Public Health has authority to make studies and investigations relating to water pollution (section 63-149; 63-202; 63-211).

Stream Standards; Classification

Wyoming laws do not specifically provide for the setting of standards of water purity, nor for classifying waters. Amendments in 1947 provide for enforcement of sanitary standards as to quality of water and as to quality of sewage treatment plant effluents "as are or may be established by law (section 63-149). No such standards appear to have been established "by law." The Department of Public Health appears to have broad powers in this field; it may "cause examination of waters to be made to ascertain their purity and fitness for domestic use or their liability to impair the health of the public or of persons lawfully using them" (section 63-202; 63-212); it has power to "make rules and regulations to prevent pollution and to secure the sanitary protection" of waters (section 63-202); it has sanitary control over the use of water employed in irrigation of vegetables (section 63-149). The statutes should give the Department the power and duty to establish standards of water purity and to classify waters in accordance with their particular uses (see Appendix "E").

There is general authority in the Department of Public Health to hold hearings, administer oaths, subpoena witnesses, and to take testimony in all matters relating to the exercise and performance of its powers and duties (section 63-147; 63-149).

Procedures are not spelled out with relation to the making of orders, granting of permits, the issuance of rules and regulations. Requirements respecting the publication of orders, rules and regulations are contained in section 63-203.

Permits

Statutory requirements for a permit system are contained in sections 63-204; 63-205; 63-206.

Orders for Pollution Abatement

Upon complaint, the Department of Public Health may issue orders prohibiting the continuance of any pollution as it affects public health and requiring the removal of any cause of pollution (section 63-207). Presumably the Department may also issue orders on its own motion. Persons aggrieved may appeal to the district court (section 63-209).

Plans and Specifications

Review of plans and specifications by the Department of Public Health is required by statute. Anyone operating a railroad, logging camp, electric plant, manufacturing or industrial plant of any kind upon or over any watershed of any public water supply system is subject to these provisions (section 63-206). Cities, towns, and all other corporations or persons must submit plans to the Department of Public Health for its advice and approval on all proposed sewerage systems or on any alterations to existing systems (section 63-204).

Federal Water Pollution Control Act (Public Law 845 - 80th Cong.)

There is no specific statutory authority to co-operate with the Federal Government in connection with this Act. However, a pattern of co-operation with Federal agencies is indicated by the biennial reports of the Department. No action was taken on the Council of State Governments' Water Pollution Control Enabling Act at the legislative session which adjourned February 19, 1948.

Division of Authority

Among the general powers and duties of the Game and Fish Commission is the power "to supervise the waters of the State pertaining to the protection, management and propagation of fish" (section 47-110). There is no further statutory implementation of this general authority.

Criminal statutes make it unlawful to discharge any "deleterious substance that might tend to destroy the fish or pollute or render the waters unfit for domestic, irrigation, stock, or any other purpose" (section 47-507). Section 9-220 makes it unlawful to poison any spring, well, or reservoir with intent to kill or injure a human being.

Enforcement

Upon application of the State Department of Public Health or of any interested person, the district court has jurisdiction in equity to enforce the Department's orders, rules and regulations (section 63-210). Violation of any provision of the Act or of any rule, regulation, or order of the State Department of Public Health is punishable by fine or imprisonment (section 63-212).

Sanitation Districts

Specific statutory authorization for the formation of sanitation districts outside of incorporated areas was provided by the legislature in January, 1950. Apparently there are adequate provisions for the formation of districts within corporate limits.

Financing of Pollution Abatement Works

Wyoming has a comprehensive revenue bond law applicable to sewerage works. General obligation bonds may also be used for financing sewerage works but the total outstanding indebtedness which can be incurred by this method is limited to 4 per cent of the assessed valuation of taxable property by constitutional limitation. This limitation does not apply to revenue bonds. Sanitation districts are authorized to issue general obligation bonds limited to 10 per cent of the assessed valuation but this provision in the Act is questioned on constitutional grounds. Revenue bond issues authorized for sanitation districts are not limited. It appears that Wyoming has adequate statutes for financing the construction of public pollution abatement works.

Water Pollution Control Program

The State is showing increased activity in the matter of water pollution control. A major investigation has recently been completed and others are contemplated within the limitations of available funds and personnel.

Only about 37 per cent of the sewered population in the State (1940) are served by sewage treatment plants. The national average is about 63 per cent.

Less than half (43 per cent) of those communities with sewer systems provide some type of sewage treatment, as compared with the national average of about 62 per cent. There would appear, from these figures, to be quite a fertile field among the cities and towns of Wyoming for promotion of water pollution abatement activities.

RECOMMENDATIONS REGARDING
STATE WATER POLLUTION CONTROL PROGRAMS

Introduction

The following discussion and related recommendations apply in general to the three States in the South Platte Basin.

Legislative Improvements Needed

In this discussion, reference is made to Appendix "E" of this report, which presents a "Suggested State Water Pollution Control Act and Explanatory Statement" (Federal Security Agency, Public Health Service, Division of Water Pollution Control, Washington 25, D.C., October,1950). The Council of State Governments has endorsed this "Suggested State Water Pollution Control Act" and recommends it to the States for favorable consideration. For many years, the State legislation on water pollution control has been gradually progressing toward uniformity. The Public Health Service hopes that the Suggested Act will facilitate this evolutionary process.

Colorado

As previously indicated (p. 42), the principal defects in the Colorado State laws relating to water pollution are that no single agency is responsible for all phases of water pollution control activity and the health department is responsible as regards public health aspects only. The Colorado Game and Fish Department is responsible for mine tailings pollution, while the City of Denver is given authority over pollution control on the upper South Platte and tributaries. The authority for water pollution control should be placed in one agency, with all interests represented. To achieve this objective, a council or committee on water pollution (p. 133) might well be incorporated in legislation. In revising existing Colorado statutes, reference should be made to the "Suggested State Water Pollution Control Act and Explanatory Statement" (Appendix "E").

Nebraska

As indicated in the review of State laws (p. 47), the existing Nebraska water pollution control laws are inadequate for present needs. Reference should be made to the "Suggested State Water Pollution Control Act and Explanatory Statement" (Appendix "E").

Wyoming

The State Department of Public Health has broad authority in water pollution control matters. Certain specific legislation would be desirable, and in this connection reference is made to Appendix "E" which contains the "Suggested State Water Pollution Control Act and Explanatory Statement."

Program

Operating Funds and Personnel

All States within the South Platte Basin need additional funds so that the personnel and equipment needed to cope with water pollution control problems can be obtained. Engineering, specialized scientific, and clerical personnel are needed. Central and field laboratory facilities devoted to water pollution control problems should be provided or greatly expanded. Another important phase of water pollution control is a public information dissemination program. Provision for this type of activity should be made in the operating budgets of the State control agencies.

The need for adequate funds to obtain necessary personnel and facilities cannot be overstressed. All three States in the South Platte Basin should provide more support for water pollution control programs.

Enforcement Program

In no other area in the United States do the people of a river basin have a greater stake in water pollution control than in the South Platte Basin. This is an area of scenic beauty, unusual recreational opportunities, valuable farming and industrial land, and progressive communities. The region's chief limitation is water, but there should be sufficient water for all needs if it is used properly. Continuing pollution detrimental to water use is not sound economy. Consequently the proper enforcement of water pollution control measures is the concern of all citizens of the Basin.

In general, the educational co-operative approach to water pollution control problems yields the greatest return on effort invested. Occasionally, however, those responsible for water pollution are not responsive to this type of approach. In such a situation, strong statutory backing plus personnel and facilities needed for thorough investigation are absolutely essential.

PRESENTATION OF DATA

Sources of Pollution

Table 17 lists all communities in the basin as to their status with regard to sewage disposal methods. The basic data from the "Inventory of Water and Sewage Facilities in the United States" (1945) were checked by field investigations in order to bring the data up to date. In addition to the domestic sewage from communities, domestic sewage from industries is often discharged to the streams along with their process wastes.

Location and magnitude of the various sources of pollution in the basin are shown graphically in Figure 3. Industrial waste equivalent populations are included in the sewered population of the community at or near which the industry is located with the exceptions of the beet sugar industry and of those slaughter houses immediately north of the city of Denver which are shown separately. Population equivalents of industrial wastes were based upon the BOD equivalents of 0.167 pounds of 5-day 20 degrees C. BOD per capita per day.

Table 19 summarizes the number and types of industries contributing significant amounts of wastes to the streams in the basin. Further detailed discussions as to the effects of the wastes are found in subsequent sections of this report dealing with the various sub-basins. In compiling the data in Table 19, a census was made of industrial establishments in the basin, outside of the Denver area. Those industries located in the City and County of Denver were the subject of a separate investigation carried out by the Denver Health Department. Its report is presented in Appendix "C".

Table 16 below summarizes the total number of significant sources of pollution in the South Platte River Basin as compiled from survey data.

Table 16 Number of Significant Sources of Pollution

Source of Pollution	No. of Each Source	Population Served (1949)	Population Equivalent to Stream (BOD)
Municipal	50	618,560	563,875
Industrial (organic)	234	---	4,400,000
Industrial (inorganic)	35	---	---

TABLE 17

SEWAGE DISPOSAL IN SOUTH PLATTE RIVER BASIN

Stream	Community	Pop. 1940	Type of Sewer System	Type of Sewage Treatment	Estimated Population Served 1949
		SUB-BASIN - MAIN STEM SOUTH PLATTE			
Colorado					
S. Platte R.	Alma	469	None	Individual systems; privies	-
"	Fairplay	739	None	Individual systems; privies	-
"	Hartsel	50	None	Individual systems; privies	-
"	Littleton	2,244	Separate	Primary settling; sep. sludge digestion; Trickling filter	2,660
"	Englewood	9,682	Separate	Enters Denver Sewers	
"	Denver: Main Plant	322,412	Separate	Primary settling; sep. sludge digestion; Chlorination	420,000
Sand Creek	East Side Plant		Separate	Primary settling; sep. sludge digestion; Chlorination.	25,000
S. Platte R.	Henderson	150	None	Individual systems; privies	-
"	Brighton	4,029	Separate	Primary settling - two-story tank with sludge digestion chamber; trickling filter.	-
"	Ft. Lupton	1,692	Separate	Primary settling; sep. sludge digestion	1,700
"	Platteville	561	Separate	None - direct to stream	700
"	Gilcrest	352	None	Individual systems; privies	-
"	LaSalle	755	Separate	Septic tank 40 x 8 x 8	1,000
"	Evans	800	Storm only	Individual systems; pit privies; septic tanks to storm sewer.	250
"	Kersey	268	Separate	Lagoon - no overflow to stream.	-
"	Masters	-	None	Individual systems; pit privies	-
"	Orchard	865	None	Individual systems; pit privies	-
"	Weldona	-	None	Individual systems; pit privies	-

TABLE IV (Continued)

SEWAGE DISPOSAL IN SOUTH PLATTE RIVER BASIN

Stream	Community	Pop. 1940	Type of Sewer System	Type of Sewage Treatment	Estimated Population Served 1949
		SUB-BASIN - MAIN STEM SOUTH PLATTE (Cont.)			
Colorado (Cont.)					
S. Platte R.	Ft. Morgan	4,884	Separate	Imhoff tank - 3 lagoons	6,000
"	Brush	2,481	Separate	Imhoff tank - modified	3,000
"	Snyder	300	None	Individual systems; privies	-
"	Merino	259	Separate	None - Direct to stream	200
"	Atwood	250	None	Individual systems; privies	-
"	Sterling	7,411	Separate	Primary settling; sep. sludge digestion.	8,000
"	Iliff	322	None	Individual systems; privies	-
"	Proctor	75	None	Individual systems; privies	
"	Crook	236	None	Individual systems; privies	
"	Sedgwick	373	None	Individual systems; privies.	
" a	Ovid	687	Separate	None - direct to stream	600
"	Julesburg	1,619	Separate	None - direct to stream	1,800
Nebraska					
S. Platte R.	Barton	-	None	Individual systems, privies	
"	Big Springs	569	None	Individual systems, privies	
"	Brule	374	None	Individual systems, privies	
"	Ogallala	3,159	Separate	None - direct to stream (Plant not used - primary settling; activated sludge; secondary settling; sep. sludge digestion)	4,600
"	Roscoe	-	None	Individual systems, privies	-
"	Paxton	551	None	Individual systems, privies	-
"	North Platte	12,429	Sanitary	None	9,300[b]

			SUB-BASIN - CACHE LA POUDRE		
Colorado					
Cache la Poudre	Bellvue	319	None	Individual systems, pit privies.	
" "	Ft. Collins	12,251	Separate	Primary settling; Hirate trickling filter with recirculation; secondary settling; sep. sludge digestion	15,000
" "	Windsor	1,811	Separate	Imhoff tank (modified); trickling filter; sep. sludge digestion	2,000
" " [c]	Eaton	1,322	Separate	Septic tank 53 x 22 x 14 (sand filter not used)	1,300
" "	Greeley	15,995	Separate	Primary settling (Chemical precip. - not used). Sep. sludge digestion	18,000
N. Fork, Cache la Poudre	Livermore	285	None	Individual systems; privies	
Boxelder Creek	Wellington	465	Separate	Imhoff tank	450
			SUB-BASIN - THOMPSON RIVER		
Colorado					
Thompson R.	Estes Park	994	Separate	Primary settling; trickling filters; sep. sludge digestion; Chlorination	850[d]
"	Bureau of Reclamation Camp, Estes Park	-	Separate	Primary settling (two-story tank with sludge digestion chamber); trickling filter; Chlorination.	300
"	Loveland	6,145	Separate	(1) Primary settling; Hirate filter w/recirculation; secondary settling; sep. sludge digestion. (2) Imhoff tank; trickling filters	6,000 2,000
"	Milliken	531	Separate	None - direct to stream	500

a - Sewage from Ovid actually enters Lodgepole Creek, but at a point near its entrance to the South Platte River.

b - Portion of city sewered to South Platte River, portion to North Platte River.

c - Sewage actually enters an unnamed minor tributary of the Cache la Poudre seven miles from the mouth.

d - Population increases during vacation season in summer to an estimated 6,000.

TABLE 17 (Continued)

SEWAGE DISPOSAL IN SOUTH PLATTE RIVER BASIN

Stream	Community	Pop. 1940	Type of Sewer System	Type of Sewage Treatment	Estimated Population Served 1949
			SUB-BASIN - THOMPSON RIVER (Cont.)		
Colorado Little Thompson R.	Berthoud	811	Separate	Imhoff Tank; trickling filter	1,000
"	Johnstown	961	Separate	None - direct to stream	1,200
			SUB-BASIN - ST. VRAIN		
Colorado St. Vrain Cr.	Lyons	654	None	Individual systems; privies	-
"	Hygiene	250	None	Individual systems; privies	-
"	Longmont	7,406	Separate	Primary settling; trickling filters; sep. sludge digestion	8,000
"	Dacona	296	None	Individual systems; privies	-
"	Frederick	652	None	Individual systems; privies	-
Boulder Cr.	Nederland	384	None	Individual systems; privies	-
"	Boulder	12,958	Sanitary	Primary settling; sep. sludge digestion	21,000
Coal Cr.	Louisville	2,023	None	Individual systems; privies	-
"	Lafayette	2,052	Separate	Primary settling; sep. sludge digestion	1,000
"	Coal Creek	261	None	Individual systems; privies	-
"	Broomfield	125	None	Individual systems; privies	-
"	Erie	1,019	None	Individual systems; privies	-
			SUB-BASIN - CLEAR CREEK		
Colorado Clear Creek	Silver Plume	139	Separate	None - direct to stream	100
" "	Georgetown	391	Separate	None - direct to stream	270
" "	Idaho Springs	2,112	Separate	None - direct to stream	2,100
" "	Golden	3,175	Separate	None - direct to stream	3,400

"	Westminster	534	Separate	Imhoff tank; trickling filter	1,200
Ralston Creek	Arvada	1,500	Separate	Primary settling; sep. sludge digestion	1,380
N. Fork - Clear Creek	Central City	706	Separate	None - Direct to stream	200
"	Blackhawk	289	None	Individual systems; privies	-
	SUBBASIN - MINOR TRIBUTARIES OF MAIN STEM SOUTH PLATTE RIVER				
Colorado					
E.Plum Creek	Palmer Lake	269	None	Individual systems; privies	-
"	Castle Rock	580	Separate	Two 3-cmpt.septic tanks; lagoons*	580
Plum Creek	Louviers	-	Separate	Imhoff tank; trickling filter	-
Bear Creek	Evergreen	350	None	Individual systems; privies	
"	Morrison	216	None	Individual systems; privies	
"	Federal Correctional Institution	-	Separate	Imhoff tank; trickling filter	500
"	Ft. Logan	-	Separate	Primary settling; trickling filter; secondary settling; sep. sludge digestion; chlorination	3,000
"	Loretto Hts. College	-	Separate	Imhoff tank	400
Cherry Creek	Parker	200	None	Individual systems; privies	-
Sand Creek	Buckley Field Naval Air Station	-	Separate	Primary settling; trickling filter; secondary settling; sep.sludge digestion	1,900
"	Fitzsimons Army Gen'l.Hosp.	-	Separate	Primary settling; trickling filter; secondary settling; chlorination; sep. sludge digestion	5,000
"	Aurora	5,500	Separate	(1) Primary settling; sep.sludge digestion (2) Imhoff tank	5,400
Lone Tree Cr.	Nunn	190	None	Indiv. systems; privies	-
" "	Pierce	343	None	Indiv. systems; privies	-
" "	Ault	761	None	Indiv. systems; privies	-
Owl Creek	Galeton	200	None	Indiv. systems; privies	-

* Effluent does not reach stream.

TABLE 17 (Continued)

SEWAGE DISPOSAL IN SOUTH PLATTE RIVER BASIN

Stream	Community	Pop. 1940	Type of Sewer System	Type of Sewage Treatment	Estimated Population Served 1949
	SUB-BASIN - MINOR TRIBUTARIES OF MAIN STEM SOUTH PLATTE RIVER				
Wyoming					
Crow Creek	Ft. Warren		Separate	Primary settling; trickling filter; secondary settling; sep. sludge digestion	5,600
" "	Cheyenne	22,474	Separate	None - direct to stream[1]	35,000
Colorado					
Crow Creek	Briggsdale	250	None	Individual systems; privies	-
" "	Cornish	140	None	Individual systems; privies	-
" "	Gill	350	None	Individual systems; privies	-
Boxelder Cr.	Elizabeth	275	None	Individual systems; privies	-
"	Hudson	295	None	Individual systems; privies	-
Lost Creek	Keenesburg	284	None	Individual systems; privies	-
"	Roggen	110	None	Individual systems; privies	-
Kiowa Creek	Elbert	325	None	Individual systems; privies	-
"	Kiowa	195	None	Individual systems; privies	-
"	Strasburg	216	None	Individual systems; privies	-
"	Wiggins	275	None	Individual systems; privies	-
Bijou Creek	Byers	400	None	Individual systems; privies	-
"	Deer Trail	387	Sanitary	None - direct to stream	450
- - -	Grover	137	None	Individual systems; privies	-
- - -	New Raymer	254	None	Individual systems; privies	-
- - -	Peete	207	None	Individual systems; privies	-
Wyoming					
Lodgepole Cr.	Pine Bluffs	711	Separate	Imhoff tank and lagoon (no sewage to stream)	-
Nebraska					
Lodgepole Cr.	Smeed	-	None	Individual systems; privies	-
"	Bushnell	252	None	Individual systems; privies	-

"	Kimball	1,725	Separate	Imhoff tank; trickling filter; secondary settling; sep. sludge digestion	2,000
"	Dix	199	None	Individual systems; privies	-
"	Potter	387	None	Individual systems; privies	-
"	Brownson	-	None	Individual systems; privies	-
"	Sidney	3,388	Separate	Primary settling; trickling filter; secondary settling; sep. sludge digestion	4,000
"	Chappell	1,093	Separate	Imhoff tank (sand filter not used)	1,250

1 Construction of a secondary treatment plant (standard trickling filters) started in 1951.

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Domestic Sewage

Detailed discussions with regard to the pollution resulting from sewered communities are presented in the various sections of the report dealing with the sub-basins. In general, the contribution of sewage pollution is proportional to the concentration of population and the magnitude of the problems resulting from pollution decrease as the density of population decreases. The major effects from discharge of sewage to the basin streams are observed in the central Colorado portion of the basin formed by a triangle including the cities of Denver, Ft. Collins and Greeley at the apices. The City of Denver constitutes the major problem simply because of its size.

Domestic sewage from approximately 618,000 persons (based upon estimated 1949 population) is discharged into the South Platte River Basin. Of this number, about 56,700 or somewhat over 9% were discharging untreated wastes into the streams. The remaining sewered population was connected to some type of treatment. Only about 66,400 , or about 11%, were connected with sewage treatment plants which provided secondary treatment of some type. Approximately 69% of the 1949 sewered population of the South Platte River Basin was located in the City of Denver. In addition, Denver sewers receive industrial wastes from packing plants and other industries which increase the equivalent population substantially. The total equivalent population of Denver is reduced by about 40% by primary treatment before discharge into the river.

Table 18 Status of Municipal Sewage Treatment, 1949

Type of Treatment	Number of:		Population Served[b]
	Municipalities[a]	Plants	
Primary	16	17	495,430
Secondary	17	18	66,410
None	15	--	56,720

a) Includes incorporated or unincorporated municipalities; other legal bodies as sanitation districts, counties, towns, significant institutions, resorts, recreation centers

b) Based upon estimated 1949 population and is not equivalent population as determined from BOD.

Industrial Wastes - General

A summary of the types and numbers of industrial contributing significant amounts of wastes to the streams of the basin is presented in Table 19. In addition, each of the industries is discussed with regard to wastes in further detail in subsequent sections. Each of the industrial

TABLE 19

ORGANIC INDUSTRIAL WASTES OF THE SOUTH PLATTE RIVER BASIN BY SUBBASINS

Subbasin	Stream	Industry[a]	No. of Industries	Estimated Population Equivalent to Stream -BOD Basis-
South Platte R., Main Stream and Minor Tributaries	So. Platte R.	Industries[b] in Denver	167	183,000
	"	Meat Packing & Slaughterhouse	5	11,300
	"	Rendering	1	750
	"	Dairy[c]	6	1,900
	"	Cannery[f]	3	9,700
	"	Condensed Milk Plant	1	210
	"	Beet Sugar Factory[f]	3	990,000
	"	Cheese[d]	1	95
	Burl.-O'Br. Canal	Paper Mill	1	7,800[g]
	Burl.-O'Br. Canal	Oil Refinery	1	4,800
	Big Dry Creek	Dairy	1	260
	Cherry Creek	Dairy	3	340
	Sand Creek	Dairy	1	350
	Sand Creek	Oil Refinery	4	2,700
	Crow Creek	Meat Packing	1	320
	Crow Creek	Oil Refinery	1	6,300
	Big Beaver Cr.	Beet Sugar Factory[f]	1	250,000
	Lodgepole Cr.	Meat Packing	1	330
	"	Beet Sugar Factory[f]	1	290,000
Cache la Poudre	Cache la Poudre	Cheese[e]	1	3,360
	"	Beet Sugar Factory[f]	3	1,100,000
	"	Dairy	1	160
	"	Slaughterhouse	2	120
	"	Rendering	1	410
	"	Vegetable Seed Washing Plant[f]	1	2,300
	"	Potato Chips	1	250
	"	Poultry Packing	2	1,390
	"	Cannery[f]	2	4,000
	Stream from Eaton	Beet Sugar Factory[f]	1	140,000

TABLE 19 (Cont.)

INDUSTRIAL WASTES OF THE SOUTH PLATTE RIVER BASIN BY SUBBASINS

Subbasin	Stream	Industry[a]	No. of Industries	Estimated Population Equivalent to Stream -BOD Basis-
Thompson River	Thompson R.	Cannery[f]	4	13,100
	"	Beet Sugar Factory[f]	2	640,000
	Buckhorn Cr.	Cannery[f]	1	1,560
	Little Thompson	Condensed Milk Plant	1	460
St. Vrain River	St. Vrain R.	Cannery[f]	1	18,000
	"	Beet Sugar Factory[f]	1	700,000
	"	Slaughterhouse	1	60
Clear Creek	Clear Creek	Brewery	1	12,200
	"	Malted Milk Plant	1	300
	"	Meat Packing & Slaughterhouse	3	2,400
		Totals	234	4,400,000[h]

Notes:

a - Industries contributing significant amounts of industrial wastes to municipal sewer systems and direct to streams.

b - All industrial wastes in Denver are lumped together for this figure. Details concerning Denver industries are presented in a subsequent section. This table does not include a breakdown by types of Denver industries.

c - Includes pasteurizing plants, bottling works, receiving stations, etc., with significant amounts of wastes. Plants discharging wastes to municipalities providing complete treatment are not included.

d - Cheddar cheese.

e - Cheddar cheese and cottage cheese.

f - Seasonal.

g - Est. pop. equiv., susp. solids basis, 35,000.

h - Rounded.

establishments outside of Denver was visited and information was gathered concerning the amount of raw materials handled, the process employed, season of operation, volume of wastes, and methods of waste disposal. From these data, estimates of the population equivalent of each industry were made, allowance being made for treatment methods employed. Copies of reports containing the information gathered were furnished the State Health Departments involved.

The largest industrial waste load in the basin is that produced by the beet sugar industry. This waste is produced over a rather short period in the fall of each year following the harvest of sugar beets. There are 12 beet processing plants located in the South Platte River Basin, all of which are in Colorado. The wastes from these establishments impose a tremendous organic pollution load on the streams of the basin during the short production season and bring about nuisance conditions in the streams during the period of their discharge. These nuisance conditions, however, appear to clear up promptly after cessation of processing operations, except in a few instances where the wastes from these factories find their way into storage reservoirs. In these instances, they continue to create local nuisance problems until the waters are displaced or greatly diluted in the reservoirs by the high runoff in the late spring.

Other industrial pollution in the basin is derived from a variety of industries. The bulk of meat packing wastes are handled by the Denver Sewage Treatment Plant, and only those wastes from relatively small meat packing establishments find their way into the streams. The canning industry is represented by a number of plants scattered throughout the basin, most of which are located along the middle third of the South Platte River. The majority of these plants are seasonal, operating from June through September or October. Wastes are discharged mostly to the streams without treatment, except for haphazard screening in some instances. Other industrial wastes are described in the sections under the various sub-basin summaries.

Table 20 - Summary of Industrial Wastes Status[1]

Type of Industry	Total Number of Plants	Number of Plants Having:	
		Treatment[2]	No Treatment
Meat Packing - Slaughtering	13	3[a]	10
Beet Sugar	12	1[b]	11
Paper Mill	1	0	1
Canneries	11	6	5
Dairies	12[c]	6	6[c]
Oil Refineries	6	6[e]	0
Rendering	2	0	2
Cheese	2	1	1
Poultry Packing	2	2	0
Condensed Milk	2	1	1
Malted Milk	1	0	1
Brewery	1	0	1
Seed Plant	1	0	1
Potato Chips	1	1	0
Ore Processing and Dredging	11	11[d]	0
Coal Mines	23	0	23
Totals	101	38	63

1. Industrial wastes of industries located in Denver not included.

2. Only significant treatment considered.

a. One Primary Settling Tank; Two Septic Tanks.

b. No beets sliced; liquid wastes evaporated; solid wastes reclaimed.

c. Plants discharging wastes to municipal secondary treatment plants not included.

d. All mills have tailings ponds.

e. All plants have oil-water separators.

Wastes of Industries Located in Denver

Practically all industries located in Denver discharge their wastes to the municipal sanitary sewerage; consequently, the wastes receive primary treatment before discharge to the river. However, a few industries discharge all or part of their wastes direct to the South Platte River. The Sanitation Division, Bureau of Health and Hospitals, City of Denver, reports the numbers and types of industries tabulated below as discharging wastes direct to the river.

Type of Industry	Number
Chemical Manufacture	2
Rubber Processing	1
Railroad Locomotive Service Centers and Washing Stations	3
Laundries	3
Meat Packing	2[a]
Brewery	1[b]

a - One plant - a portion of the wastes only.
One plant - total wastes.

b - Portion of wastes only.

A discussion of the water pollution significance of these independent industrial waste discharges is presented in the section of this report entitled Main Stem and Minor Tributaries.

Oil and grease from railroad roundhouses cause serious pollution.

The industrial wastes discharged to the sanitary sewers of Denver are estimated to have a population equivalent of 163,000 on a BOD basis. This figure was obtained by subtracting the estimated sewered population from the estimated total population equivalent. Reference is made to Table SP-9 which served as the basis for these estimates.

The major portion of the waste load of Denver industries probably originates in nine meat packing plants. The types and number of plants of industries, which it is believed contribute significant amounts of industrial wastes to Denver sewage, are tabulated below:

Denver Industries with Significant Waste Loads Connected to Sanitary Sewers

Rendering	2[a]	Dairy Products:	
Meat Packing	9[b]	Butter, Ice Cream, Milk, Cream, Cottage Cheese	65
Brewery	1	Cheese	3[d]
Stockyards	1	Potato Chip Manufacture	6
Laundries	37[c]	Salad Dressing	6
Syrups & Honey	12	Preserves, Jams, Jellies, and Fruit Butter	4
		Pickled Fruits & Vegetables, Sauces & Seasonings	9
		Vegetable and Fruit Canning	1

Notes:
a - Independent of meat packing plants.
b - Most of these plants have own rendering works.
c - Excluding hand laundries.
d - Excluding cottage cheese.

Industrial Wastes Outside of Denver

Beet Sugar Industry - The industry contributing the preponderant share of the waste load to the streams of the basin is the beet sugar industry with 12 operating plants scattered throughout the basin. Five plants are straight houses, and six plants are Steffens houses. The final molasses of the straight houses is shipped to the Steffens houses. Additional sugar is recovered from the Steffens house molasses at one special plant; the wastes of this plant are considered to be negligible.

The period of factory operation extends usually from about the first part of October to sometime in December. The acreage of beets, yields, and other factors govern the quantity of beets to process and thus the season length.

Settling of the wastes in ponds prior to discharge is practiced to some extent. This ponding accomplishes considerable removal of suspended matter, lime cake, and silt, but no consistent reduction of BOD is accomplished. A few factories lagoon the lime cake waste over the entire season without discharge to the streams.

The pollutional characteristics and volumes of the components of the wastes from straight and Steffens factories were investigated during the 1949 season at three factories. The results of this survey are included in a discussion of the source, strength, and methods of disposal of wastes from beet sugar manufacture presented in Appendix "F".

The results of the surveys were applied to the particular components produced at each factory and with allowance for disposal methods employed give the population equivalents shown below.

Table 21 Population Equivalents of Beet Sugar Factories in South Platte River Basin

Sub-Basin	Factory Location	Tonnage	Estimated Population Equivalent of Waste to Streams BOD Basis
South Platte River	Brighton	1,900	180,000
	Ft. Morgan	2,000	450,000
	Brush	1,650	250,000
	Sterling	1,550	360,000
	Ovid	1,900	290,000
Cache la Poudre	Ft. Collins	2,975	710,000
	Windsor	1,640	210,000
	Eaton	1,600	140,000
	Greeley	1,625	180,000
Thompson	Loveland	2,500	640,000
	Johnstown	(Special Process)	(Negligible)
St. Vrain	Longmont	3,000	700,000

Canning Industry - Information concerning the number and operation of canneries discharging wastes to the streams of the basin, together with the population equivalents of the wastes, are presented in Table 22. The canneries within the City of Denver are not included in the table. The Colorado Manufacturers Directory lists one vegetable and fruit cannery in Denver. The pollution contributed by all Denver industries was estimated as a group.

A few of the canneries discharge to municipal sewers as designated in Table 22. With one exception, the canneries make little attempt to alleviate the waste load of their processes. In fact, disposal of solids to the sewers is the general practice even when these solid wastes originate apart from the liquid wastes and could be disposed of in dumps.

Table 22 - Summary of Canning Industry in South Platte River Basin

Subbasin	Number and Type of Plant Contributing Wastes to Streams	Product	Operating Season		Estimated Population Equivalents to Streams -BOD Basis-
			Starting Date	Duration in Days	
South Platte River Main Stem Exclusive of Denver	3 Vegetable Canneries[a]	Pickles	Continuous		-
		Peas	6/15-20	20	2,800
		Beans Green & Wax	7/20-25	20-30	2,100
		Tomatoes	8/25	30-40	3,200
		Tomato Products	8/25	30-40	7,500
		Sauerkraut	Slicing - Aug. & Sept. Canning - Aug. & Sept. and Winter		200
Cache la Poudre	1 Vegetable Cannery[b]	Corn	8/15-25	30	3,400
		Hominy	Winter	-	-
		Peas	6/15-20	30	3,500
		Sauerkraut	Slicing - Aug. & Sept. Canning - Winter		-
	1 Cherry Cannery[c]	Cherries	7/15	20	500
	1 Pickle Packing Plant	Pickles	Continuous		-
Thompson	1 Vegetable and Cherry Cannery	Peas	6/15-20	30	9,600
		Beans Green & Wax	7/20-25	30	1,000
		Cherries	7/15	20	1,000
	4 Cherry Canneries[d]	Cherries	7/15	20	5,060
St. Vrain	1 Vegetable Cannery	Peas	6/15-20	30	8,800
		Red Beets	8/1-5	20-30	18,000
		Lima Beans	9/1	20-25	2,200
		Pumpkins	10/1	30-35	7,500
		Pork & Beans	Winter	-	-
		Red Kidney Beans	Winter	-	-

[a] Two canneries are connected to municipal treatment plants providing primary treatment.

[b] Cannery connected to municipal treatment plant providing primary treatment. Wastes were by-passed in 1949 - new pumps installed to provide treatment, 1950.

[c] Connected to municipal plant providing complete treatment.

[d] Two cherry canneries connected to municipal plant providing complete treatment.

Meat Packing Industry - The greatest portion by far of the meat packing of the basin is carried on in plants located in the City of Denver. These plants are discussed in the section concerning the industrial wastes of Denver. Thirteen small slaughterhouses contributing wastes to the streams exist outside of Denver. The majority of these are located in the vicinity of Denver. The population equivalents of the wastes of these slaughterhouses are tabulated below. One plant provides primary settling for its wastes; a few others have ineffective, inoperative catch basins. Two small plants utilize small septic tanks.

Table 23 Summary of Meat Packing Industry in South Platte River Basin

Sub-Basin	Number of Plants	Estimated Population Equivalent of Wastes to Streams -BOD Basis-
South Platte[a]	5[b]	11,300[c]
Cache la Poudre	2	120
St. Vrain	1	100
Clear Creek	3	2,400
Lodgepole Creek	1	330
Crow Creek	1	320

a - Exclusive of Denver
b - One plant contains rendering works for own offal.
c - One plant provides primary treatment.

Rendering Industry - Most of the meat packing plants in the City of Denver operate their own rendering plants; in addition, two independent rendering plants exist in the city. The pollution contributed by the rendering plants in Denver is included in the estimate for all Denver industries. The population equivalents of the rendering plants in the basin outside of Denver are tabulated below.

Table 24 Rendering Plants in the South Platte River Basin

Sub-Basin	Number of Plants	Estimated Population Equivalent of Wastes to Streams -BOD Basis-
South Platte[a]	2	920
Cache la Poudre	1	410

a - Exclusive of Denver.

Mining Industry - The number and sub-basin location of the various mining industry operations are tabulated below and discussed in succeeding paragraphs.

Table 25 Summary of Mining Industry in South Platte River Basin

Sub-Basin	Number of Plants	Mining Industry Operation
South Platte River	1	Placer Gold Dredge
	2	Coal Mine
St. Vrain	1	Ore Mill
	19	Coal Mine
Clear Creek	9	Ore Mill
	2	Coal Mine

Ore Processing Mills - The recovery of valuable concentrates of ores in milling operations produces a waste consisting of a suspension of the powdered inorganic constituents of the ore. This suspended material is referred to as "tailings". At the time of this investigation seven ore processing mills were in operation in the basin out of a total of 11 in existence. These mills process 250 tons of ore daily for gold, lead, silver, zinc, and copper recovery. Operation of some of the mills is intermittent.

The introduction of tailings to the streams of the basin has been recognized as objectionable for many years and control measures have been attempted. The major objection to the unregulated discharge of the mine tailings to the stream is the silting which results therefrom. The accumulation of silt raises the stream bed and forms bars and mud banks. This has a serious effect on fish life in the stream and also brings about excessive maintenance costs to irrigators and to other water users for silt removal. In some instances toxic substances such as cyanides are liberated with the tailings which may bring about serious consequences should the water containing them be used for domestic or farm purposes. These toxic substances are also quite detrimental to fish and other aquatic life in the stream. Fortunately the use of cyanides for processing ores is decreasing as better recovery processes are found. The control measures consist of ponding of the tailing suspension, permitting the suspended matter to settle out prior to discharge of the water to the stream. All mills in the basin employ such ponding methods. The pond of one mill was not performing satisfactorily when inspected. Some ponds have not been satisfactorily located, that is, the embankments of tailings forming the pond have not been located at sufficient distance from the streams to prevent their erosion into the streams, especially during high flows. It is realized that ideal location of ponds is difficult in some cases, due to the precipitous canyons in which the mills are located.

Many old tailing dumps, created in the more active mining era when tailing disposal was uncontrolled, exist so near the streams that they are continuously being eroded by storm runoff and high flows into the surface waters. The stabilization by nature of the existing tailing dumps so that they will not erode to the streams will probably require a great many years; artificial stabilization would be an enormous task.

Hard Rock Mining - The mining operations of themselves produce no waste problem except for drainage in some instances. Some abandoned mines in the past have dumped worthless rock, removed incident to recovery of valuable ores, in or adjacent to streams so that the washing of the finer particles into the streams by erosion occurs.

One abandoned mine discharges a heavy flow of highly mineralized acid waters by natural drainage from a horizontal shaft. Characteristics of the water as determined by analyses include:

Copper - 44 ppm.
Iron - 348 ppm.
Lead - 0.125 ppm.
Hardness - 12,200 ppm.
pH - 2.5

The volume was estimated at 200 gallons per minute. The stream flow at the point where this drainage enters is sufficient to reduce the concentration of the waste constituents to practically negligible proportions as determined by analyses of the stream waters from above and below the point of entry.

Coal Mining - The sole liquid waste from coal mining operations in the basin is mine drainage. No coal washeries or coke manufacturing plants exist.

The mine drainage in some cases enters surface streams; however, many of the mines are located in the higher levels of the piedmont section several miles from main streams, and in most cases the drainage waters seep away or evaporate before reaching the streams. Some of the mine drainage water is high in the carbonate, chloride, and sulphate salts of sodium. An excess of alkali salts in water is injurious to vegetation. Nevertheless, a few of the mines discharge the drainage water directly to irrigation ditches and it is apparently in demand for this purpose and for stock watering.

Placer Gold Dredging - One placer gold dredge is currently operating in the plain adjacent to the South Platte River near its headwaters. This dredge separates gold from 600 cubic yards of gravel each hour. The dredge operates in an artificially created pond. The discharge from this pond carries in suspension a high concentration of silt washed from the gravel. This silt is settled from the overflow in a series of basins before it is discharged to the river.

Oil Refining - A total of five oil refineries discharge wastes to watercourses in the basin. All of these plants maintain oil-water separators for recovery of oil from the wastes. One refinery disposes of its wastes by broad irrigation and no wastes from this refinery enter the natural drainage. Two refineries provide holding ponds. No other measures for treatment of the wastes actually discharged from the refineries are provided. The population equivalent (B.O.D. basis) of the five refineries discharging wastes into the natural drainage is conservatively estimated to be about 13,800. Refinery wastes represent an objectionable type of pollution from the standpoint of all water uses.

Table 26 Oil Refining Industry in the South Platte River Basin

Subbasin	No. of Refineries	Location	Capacity Barrels Per Day	Treatment	Disposal
South Platte River	5	Denver	18,000	Oil-Water Separators	2 to Sand Creek near mouth 1 to Sand Creek via ponds and swamps 1 to Burlington Ditch 1 to Broad Irrigation of Wasteland
Crow Creek	1	Cheyenne	10,000	Oil-Water Separators and Ponds	To Crow Creek

Miscellaneous Industries - Other industries in the basin having significant waste loads are shown in Table 27. The smaller dairy product establishments contributing wastes to city sewers are omitted. The wastes from the laundry industry are not included.

Table 27

Miscellaneous Industries in South Platte River Basin

Industry	Sub-Basin	No. of Plants	Location	Disposal	Estimated Population Equivalent to Stream - BOD Basis -
Milk[a]	South Platte	11	6-Near Denver	Direct to streams	1,000
			3-Lower South Platte	To Municipal Plant providing primary treatment	650
			2-Lower South Platte	Direct to stream	1,200
	Cache la Poudre	1	Greeley	To Municipal Plant providing primary treatment	160
Condensed Milk Plant	South Platte	1	Ft. Lupton	To Municipal Plant providing primary treatment	210
	Thompson	1	Johnstown	To irrigation ditch and to streams	460
Cheese Factory	South Platte	1	Ft. Morgan	To Municipal Plant providing primary treatment	100
	Cache la Poudre	1	Ft. Collins	Direct to stream	3,360
Poultry Packing	Cache la Poudre	2	Ft. Collins	To Municipal Plant providing intermediate treatment	1,300[b]
			Greeley	To Municipal Plant providing primary treatment	90
Potato Chip Manufacture	Cache la Poudre	1	Greeley	To Municipal Plant providing primary treatment	250
Vegetable Seed Plant[c]	Cache la Poudre	1	Greeley	Direct to stream	2,300[c]

Notes: a - Includes pasteurizing plants, bottling works, receiving stations, etc., with significant amounts of waste. Plants discharging wastes to municipalities providing secondary treatment are not included.

b - Turkey processing plant - season October to January.

c - Cucumber, squash, and cantaloup seed washing and drying plant - season September and October.

USES OF WATER RESOURCES

Basin Water Resources and Water Usage

The basin water resources consist of surface, ground, and transmontane diversion water. The present annual supply from all sources is about 2,800,000 acre-feet. Projects now under construction, or in the planning stage, will greatly increase the transmontane diversion supply and will furnish water for hydro-electric power, as well as supplement present irrigation supplies. Surface water supplies have been greatly over-appropriated for irrigation usage so that irrigation by pumping from ground water sources has greatly increased in recent years. This is especially true in the lower reaches of the main stem where ground water is available at depths of from 40 to 200 feet. In 1939 about 240,000 acre-feet of water was pumped for irrigation purposes. It is anticipated that some of the additional water imported into the basin will serve to recharge ground water storage, especially at shallow depths, and thus provide additional water for pumping.

Public Water Supplies

In 1940 approximately 419,000 persons in the basin were served with water supplies from surface sources. Table 28 lists all communities in the South Platte Basin which are served by surface water supplies (all other communities use ground water sources). Approximately four-fifths of those consumers using surface water supplies were served by the Denver supply which is the most extensive in the basin, and which serves practically the entire Denver metropolitan area. In 1949 the Denver Water Board estimated the total population served by this system as about 481,000. On this basis, present population in the basin served by surface supplies would exceed 550,000. About 30% of the elaborate Denver supply is obtained by transmontane diversion via the Moffat Tunnel. The remainder is supplied from east slope sources, principally from the South Platte River with about 8% from Cherry and Bear Creeks. Figure SP-1 shows the main features of the Denver water supply sources. Table 29 shows the water consumption for Denver from 1918 to 1949. For the most part, remaining surface water supplies are obtained from streams or impoundments in the mountainous regions which are subjected to little or no pollution. There are no public water supplies taken directly from streams in the plains regions, probably because stream flows are not reliable, or because of undesirable high mineral content, or because of pollution.

Varying amounts of water are used throughout the basin for manufacturing and railroad use. For the most part, this water is obtained from the various municipal supplies. However, sugar factories or canning plants in rural areas use other available surface or ground water supplies.

Table 28 - Surface Water Supplies in the South Platte River Basin

COMMUNITY	1940 POP.	DESCRIPTION OF SUPPLY
Littleton, Colo.	2,244	South Platte River - Infiltration gallery and two shallow wells. Only treatment chlorination.
Denver	322,412	Two sources of supply used: (a) South Platte River - approximately 70% of supply from this source together with Bear Creek and Cherry Creek. Intake at Platte Canyon. Bear Creek intake at Morrison. Cherry Creek infiltration galleries at Sullivan. Drainage area, 3,270 sq. mi. above intakes. Three impoundments are located on Platte headwaters (193,400 A.F.). Treatment by two rapid sand filtration (85.0 M.G.D.) and one slow sand filtration (30.0 M.G.D.) plants and by chlorination. (b) Fraser River - approximately 30% of supply from this source. Diversion to east slope of divide through Moffat Tunnel to S. Boulder Creek to Ralston Creek Reservoir (10,700 A.F.). Rapid sand filtration and chlorination (56.0 M.G.D.).
Fairplay	739	Beaver Creek and spring. Infiltration gallery from Beaver Creek. Spring uncovered. Hypochlorinator for emergency use only (0.25 M.G.D.).
Evergreen	350	Water taken from Bear Creek below Evergreen Dam. Treated by pressure filters. Hypochlorinator. (0.20 M.G.D.).
Morrison	216	Direct from Bear Creek. Use zeolite filters - chlorinated (0.25 M.G.D.).
Palmer Lake	269	Impounded from (1) Thompson Creek and (2) Ice Cave Canyon. No treatment. (0.25 M.G.D.).
Silver Plume	139	Infiltration gallery parallel to Clear Creek. No treatment. (0.05 M.G.D.).
Georgetown	391	Diverted from Leavenworth Creek to concrete reservoir at edge of town. Flows through two power company reservoirs. Chlorination.
Empire	174	Intake on Mad Creek. Watershed nearly inaccessible. No treatment.
Idaho Springs	2,112	Diverted from Chicago Creek and Devil's Canyon. Soda Creek used as emergency. Chicago Creek main source. Diverted to filter basin and chlorinated(0.25 MGD).

Table 28 (Cont'd). Surface Water Supplies in South Platte River Basin

Community	1940 Pop.	Description of Supply
Central City	706	Miners Gulch, Peck Gulch and protected spring to 0.2 MG Reservoir. No treatment.
Blackhawk	289	Protected springs in Four Mile Canyon to 1.5 MG Reservoir (bad order). Use Central City as supplemental supply. No treatment.
Golden	3,175	Long Lake Reservoir (1400 A.F.). Beaver Creek used as emergency. Supply chlorinated. (0.50 M.G.D.)
Nederland	384	Boulder Creek. No treatment. (0.25 M.G.D.)
Boulder	12,958	Impounded supply (3500 A.F.). Protected watershed, City owned (6,000 acres). Chlorinated (6.0 M.G.D.).
Louisville	2,023	South Boulder Creek to Marshall Lake to Louisville Reservoir (160 A.F.). Rapid sand filtration and chlorination (1.0 M.G.D.).
Lafayette	2,053	South Boulder Creek to rapid sand filtration and chlorination (0.5 M.G.D.)
Erie	1,019	South Boulder Creek to South Boulder Canyon, irrigation ditch to Erie Reservoir (120 A.F.). Rapid sand filtration and chlorination. (0.5 M.G.D.)
Lyons	654	North St. Vrain Creek - inadequate supply. Treatment by pressure filters. (0.25 M.G.D.)
Longmont	7,406	North and South St. Vrain Creeks. Treatment by 5.0 M.G.D. rapid sand filtration plant and chlorination. Inadequate capacity.
Estes Park	994	Two sources of water used: (a) Glacier Creek - diversion to sand trap and chlorinator. About 1.0 M.G.D. (b) Black Canyon - diversion to small settling basin. No treatment. About 1.0 M.G.D.
Loveland	6,145	Thompson River below Drake. Rapid sand filtration. Chlorination. (6.0 M.G.D.)
Berthoud	811	Thompson River to Handy Irrigation Ditch to settling basins (2.0 M.G.). Rapid sand filtration and chlorination. Storage in Turner Lake for winter use.

Table 28 (Continued)

Johnstown	961	Thompson River to Home Supply Ditch to two reservoirs (total 275 A.F.). Coagulation, sedimentation, rapid sand filtration, and chlorination. (1.5 M.G.D.).
Ft. Collins	12,251	Cache la Poudre River. Rapid sand filtration and chlorination. Patrolled and protected watershed (9.0 M.G.D.).
Greeley	15,995	Cache la Poudre River three miles below North Fork junction. Patrolled watershed. Impoundment at Milton Seamen Dam on North Fork 3/4 mile above junction with main stream. Slow sand filters, rapid sand filters, and chlorination. (9.0 M.G.D.).
Cheyenne, Wyo.	22,474	Three impoundments on Upper Crow Creek, (10,700 acre-feet), and 14 wells (4.5 M.G.D.). Surface supply treated by aeration, rapid sand filtration, and chlorination. ($Cl_2 - NH_3$). (12.0 M.G.D.)
TOTAL	419,344	

TABLE 29

CONSUMPTION OF FILTERED WATER
DENVER PUBLIC WATER SUPPLY

Year	Daily Average G.P.D.	Estimated Population	Gallons per Capita
1918	49,109,837	268,000	183
1919	53,803,655	270,000	199
1920	53,146,745	272,000	195
1921	52,733,472	276,000	191
1922	55,904,248	285,000	196
*1923	53,759,935	295,000	182
1924	60,344,769	306,000	197
*1925	55,203,076	313,000	176
1926	57,812,406	316,000	183
1927	60,932,356	320,000	190
1928	65,442,432	323,000	203
*1929	61,635,123	325,000	190
*1930	67,831,863	326,000	208
1931	67,401,205	329,000	205
*1932	62,886,311	331,000	190
**1933	58,687,506	331,000	177
**1934	61,694,109	338,000	183
**1935	51,867,918	340,000	153
*1936	57,630,629	345,000	167
1937	61,286,301	350,000	175
1938	56,519,452	354,000	160
1939	69,947,370	360,000	194
1940	64,034,645	370,000	173
1941	60,327,096	380,000	159
1942	70,788,521	405,000	175
1943	77,840,685	407,000	191
1944	76,710,000	409,000	188
1945	71,035,342	414,000	172
1946	79,969,315	423,000	189
1947	80,397,000	440,000	183
1948	90,907,562	460,000	198
1949	88,615,644	481,000	184

* Irrigation on alternate days only.
** Special irrigation restrictions.

Taken from 1949 Report of the Denver Board of Water Commissioners.

Irrigation

A major water use in the basin is for irrigation. Soils of the piedmont areas are quite fertile and are suitable for cultivation and, when supplied with adequate water, produce excellent yields. The use of surface waters for irrigation purposes depletes the natural stream flow in proportion to the amount of water appropriated for this purpose. The rights to water usage in the basin, as in most arid or semi-arid states, are based upon the doctrine of appropriation, under which, first in time is first in right, and beneficial use is the basis of measure and limit of the right. The water in surface streams is owned by the public, and its use is administered by the public, usually through the State Engineer. The right to use waters from streams is based upon priority of appropriation. Appropriations are adjudicated in amount from time to time, so as to insure proper division of the supply from any given source among all users, and to reallocate abandoned rights among remaining users. All of the surface flows from the basin streams had been appropriated before 1900. However, any potential water user may file a claim to cover his needs, or old users may file claims for additional water with the State Engineer. If the claims are recognized and adjudicated by the courts, the claimants are then entitled to the use of water, provided claims of those with prior rights are first satisfied. Such procedure results in the appropriations of water to an extent far beyond the capacity of the streams to satisfy them. Therefore, few users except for those with the oldest rights ever have sufficient water to satisfy their claims. Water rights are administered without fear or favor and in extreme drought only those with the oldest rights receive any water at all. Because of this situation, the acreage of irrigated lands in the basin has remained more or less static for the past 50 years or more, as it is governed by the amount of stream flow available for irrigation purposes.

Table 30 shows the irrigated acreage in the South Platte Basin in Colorado for a typical year, 1944, as taken from the biennial report of the Colorado State Engineer for 1943-1944. Water districts in the division outside of the South Platte Basin were omitted from the table. Figure 5 shows the area covered by Colorado Irrigation Division No. 1, which includes all of the South Platte River Basin in Colorado. Diversions along the streams of the South Platte River system are shown in the various sub-basin sections of the report. Water storage in the basin available for irrigation and other purposes for a typical year, 1944, is shown in Table 31. Peak storage is available during the summer months due to the heavy runoff of streams in the area following the heavy snow melt in May and June. Irrigation usage is reflected in decreased storage from July to October.

Transmontane Diversions

It is anticipated that completion of the Colorado-Big Thompson transmontane diversion project by the Bureau of Reclamation will make available somewhat less than 300,000 additional acre-feet of water annually for irrigation purposes in the basin below Platteville, principally on the Cache la Poudre, Thompson and St. Vrain tributary drainage systems (See

TABLE 30

SUMMARY OF WATER COMMISSIONER'S CROP REPORT FOR THE IRRIGATION SEASON OF 1944 IRRIGATION DIVISION NO. I, COLORADO, EXCLUDING DISTRICTS IN THE NORTH PLATTE AND KANSAS RIVER BASINS

Dist. No.	First Day Water Used From Natural Stream	Last Day Water Used From Natural Stream	No. Acre Feet Used For Season	Total No. Acres that can be Irrigated	Acres Irrigated**			Total Irrigated Acres
					Alfalfa	Natural Grasses	Cereals	
1	5-8-44	10-31-44	306,757	163,912	35,342	14,505	28,797	151,628
2	5-1-44	10-31-44	374,259	226,700	39,462	10,628	80,277	219,670
3	5-7-44	11-6-44	332,900	380,000	64,616	5,007	72,859	264,160
4	5-7-44	10-31-44	160,831	167,000	38,350	305	72,690	141,210
5	5-16-44	10-31-44	113,919	112,235	34,830	8,865	49,215	111,635
6	5-1-44	10-29-44	102,316	*195,335	28,492	61,125	45,605	*172,414
7	5-1-44	10-31-44	133,624	117,180	13,505	1,230	52,314	95,121
8	4-1-44	10-31-44	126,884	120,000	9,826	958	6,141	23,635
9	3-1-44	10-31-44	33,642	16,349	4,818	1,653	5,069	14,064
23	4-27-44	10-31-44	E.120,000	50,000	.....	40,000	.....	40,000
64	4-9-44	11-31-44	282,216	195,184	37,665	29,926	41,789	171,884
TOTALS			2,087,348	1,743,895	306,906	174,202	454,756	1,405,421

E - Estimated

* Acreage reported too high since 1922. Land cruise of 1930 shows irrigated area to be 72,142 acres.

** Additional crop figures shown on Continuation Sheet of this Table.

TABLE 30 (Continuation Sheet)

Dist. No.	Acres Irrigated								
	Orchards	Market Gardens	Potatoes	Sugar Beets	Beans	Peas	Cabbage	Corn	Other
1	152	371	2,069	13,471	20,925	....	17	25,714	10,265
2	340	12,059	11,777	27,668	23,460	760	2,192	......	11,047
3	1,567	3,915	29,079	35,308	11,554	570	803	......	38,882
4	2,020	645	7,802	9,020	3,260	2,210	421	2,570	1,917
5	90	670	200	16,525	.....	.....	540	......	700
6	655	2,562	335	4,320	1,090	465	139	18,438	9,188
7	1,632	10,803	156	1,540	867	335	1,197	6,585	4,957
8	31	2,211	10	162	10	.....	.....	.....	4,286
9	89	350	.....	175	35	.....	100	1,340	435
23	.....	.....	.....	.....	....	.....	.....	.....	.....
64	125	983	3,602	16,699	5,259	0	30	29,885	5,921
TOTALS	6,701	34,569	55,030	124,888	66,460	4,340	5,439	84,532	87,598

TABLE 31

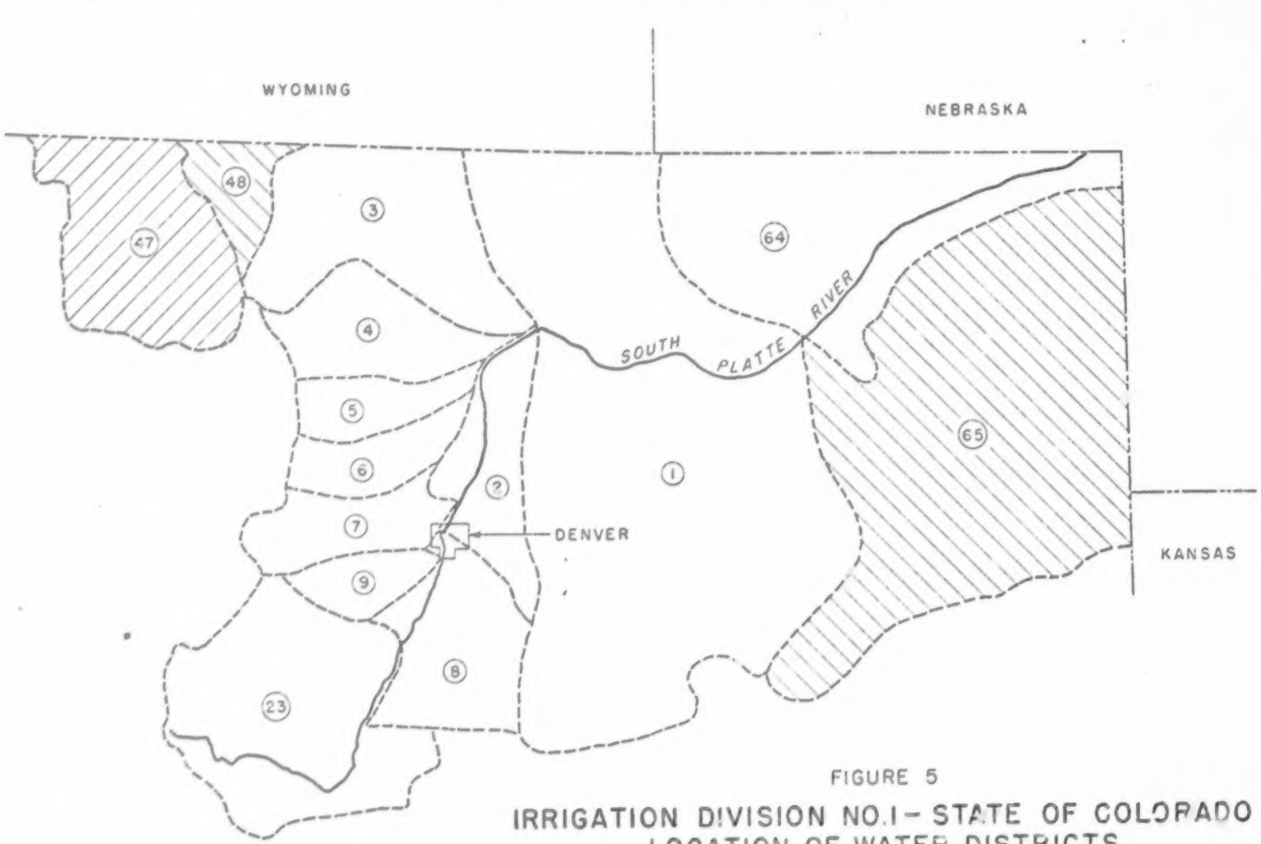
The following is a statement of Water in Storage in South Platte River Basin in Colorado from January 1 to December 1, 1944.

Values in Acre-Feet

District No.	January	February	March	April	May	June
1	63,165	82,172	102,309	116,366	131,313	134,111
2	21,946	29,072	41,089	51,375	81,227	92,483
3	65,607	70,878	74,916	81,142	102,981	129,104
4	37,852	37,795	39,644	40,125	65,495	89,753
5	9,360	10,000	10,902	11,937	23,280	31,299
6	17,149	17,913	17,305	17,118	23,531	35,530
7	8,122	12,102	12,778	4,402	5,692	13,879
8	15,247	17,565	16,970	16,451	17,799	17,229
9	2,811	3,199	4,022	4,372	7,554	8,468
23	166,281	162,648	163,031	164,678	178,380	185,286
64	59,549	74,291	83,321	102,284	122,781	117,517
TOTALS	467,089	517,635	566,287	610,250	760,033	854,659
City of Denver	187,389	184,282	183,418	183,255	196,445	209,189
Bal. for Irrig.	279,700	333,353	382,869	426,995	563,588	645,470

District No.	July	August	September	October	November	December
1	112,045	73,523	19,425	2,590	2,489	30,305
2	82,402	64,915	30,531	15,296	13,095	18,844
3	122,912	101,894	43,600	29,155	29,792	33,300
4	85,604	74,062	48,078	37,717	34,723	34,767
5	31,316	21,082	11,903	6,344	6,221	5,954
6	34,222	30,128	22,130	17,394	15,841	14,590
7	13,126	12,908	9,575	8,221	7,722	7,076
8	16,100	16,282	14,253	12,100	14,178	14,842
9	7,232	5,381	2,857	2,065	1,721	1,700
23	185,000	182,862	173,312	168,307	162,491	160,302
64	95,807	80,546	37,075	14,757	27,145	39,109
TOTALS	785,766	663,583	412,739	314,046	315,418	360,789
City of Denver	206,716	207,723	195,363	187,062	183,160	180,653
Bal. for Irrig.	579,050	455,860	217,376	126,984	132,258	180,136

From Colorado State Engineer Report 1943-1944.



NOTE: Cross hatched areas not in South Platte River Basin. Districts indicated by ○

FIGURE 5

IRRIGATION DIVISION NO.1 – STATE OF COLORADO
LOCATION OF WATER DISTRICTS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

Exhibit I). Should the Blue-South Platte Project, now under consideration by the Bureau of Reclamation, be approved, another 430,000 acre-feet of transmontane diversion water will be available for use in the area from the North Fork to Ft. Lupton and eastward to Kiowa Creek (See Exhibit II). This project will furnish 49,000 acre-feet of supplementary water for Denver municipal use. There are currently about 15 diversions of water from other sources into the South Platte Basin, including 3 from the North Platte River. Table 32, taken from the report of the Colorado State Engineer for 1944, shows the diversions to the South Platte Basin totaling about 61,000 acre-feet. Of this amount, 16,000 acre-feet were utilized by the Denver Water Supply. A large diversion is made into the basin from the North Platte River in Nebraska. This water is used primarily for power purposes and enters the South Platte near its mouth at North Platte, Nebraska, after being introduced into the basin near Paxton, Nebraska, and flowing through some 38 miles of canals and two reservoirs to a power plant near North Platte, Nebraska.

TABLE 32

TRANSMONTANE DIVERSIONS TO SOUTH PLATTE RIVER BASIN
- STATE OF COLORADO -

Irrigation Division No. 1
for 1944

Name of Diversion	From Dist.	To Dist.	Source of Supply	First Day	Last Day	Acre Feet
Deadman Ditch	48	3	Laramie River	- - -	- -	0
Laramie-Poudre Tunnel	48	3	Laramie River	5-21	7- 3	9,082
Skyline Ditch	48	3	Laramie River	5-21	7-18	10,576
Lost Lake Ditch	48	3	Laramie River	5-25	6-17	217
Columbine Ditch	48	3	Laramie River	- - -	- -	0
Bob Creek Ditch	48	3	Laramie River	- - -	- -	0
Sand Creek Ditch	48	3	Sand Creek	5-26	6-10	1,705
Michigan Ditch	47	3	North Platte R.	6-15	8- 5	1,797
Cameron Pass Ditch	47	3	North Platte R.	6-19	7-15	186
Grand River Ditch	51	3	Colorado River	5-30	9- 2	16,629
Moffat Tunnel	51	6-7	Colorado River	5-31	11- 7	16,196
Williams Fork Tunnel	51	7	Colorado River	7- 4	9-17	3,941
Berthoud Pass Ditch	51	7	Colorado River	6-20	8- 5	430
Eureka Ditch	51	4	Colorado River	6-25	9-10	95
TOTAL						60,854

Irrigation Division No. 1 comprises South Platte River drainage basin, except for Districts 47 and 48 in North Platte River Basin and District 65 in Kansas River Basin.

From Colorado State Engineer Report 1943 - 1944

Recreational Use

The headwaters of the South Platte River and its perennial tributaries are located in rugged mountainous areas of considerable scenic grandeur. These regions are attractive to tourists and residents alike and constitute popular summer resort areas. It is estimated that the tourist trade is worth nearly $200,000,000 to the State of Colorado alone. In 1949, over 1,000,000 persons visited the Rocky Mountain National Park. Of special interest from this standpoint is the use of these headwater streams for game fishing. In their natural state, these streams supported a rather ample fish life. The influx of population and industry, together with improved transportation facilities and the construction of good roads into these areas, has resulted in some depletion of the fish resources of these streams. The Colorado Game and Fish Department has been instrumental in establishing fish hatcheries which serve as sources from which these streams are periodically re-stocked with game fish. The most popular fishing streams are found in the headwaters of the Cache la Poudre and Thompson Rivers; the St. Vrain, Boulder, and Bear Creeks; and in the South Platte River and tributaries above Waterton. The quality of water in these mountain streams is, for the most part, excellent for the propagation and maintenance of game fish.

The waters of Clear Creek above Golden appear to be of good quality for the support of fish life at the present time. According to historical records, this creek was an excellent source of fish life prior to extensive mining developments along its waters. At the present time there are 9 ore mills located in the Clear Creek Basin. These mills do not operate continuously, nor do they use cyanides in the processing of the ores. Pollution resulting from ore processing operations is confined largely to the escape of tailings into the watercourse. However, in the early days, there was considerable sluicing and hydraulic operations in the Clear Creek canyons, which resulted in very profound and permanent changes in the character of the stream beds. These changes were detrimental to the propagation of normal fish life in the streams. For some years past, the Colorado Game and Fish Department has had the responsibility of policing the streams in the state to prevent excessive discharge of tailings and other mine wastes into the streams. They have been active in this regard, and their efforts have resulted in the clearing up of a number of streams formerly made unsuitable for fish life because of high silt content or toxic materials brought about by the unregulated discharge of tailings into the streams.

It is feasible to maintain the headwaters of all of these streams as recreational areas and to prevent undue pollution damage. There are no large centers of population currently in existence in these areas, with the possible exception of the region immediately adjacent to Rocky Mountain National Park and along the Thompson River Canyon and on Clear Creek.

Some of the reservoirs on the Colorado-Big Thompson Project are located adjacent to popular summer resort areas. Of especial interest are the Granby, Shadow Mountain, Mary's Lake, Estes, and Horsetooth Reservoirs. The first four are located immediately adjacent to Rocky

Mountain National Park, the Mary's Lake and Estes Reservoirs being adjacent to the town of Estes Park. The use of these reservoirs for recreational purposes will necessitate measures being taken to control water pollution. Specifically, the discharge of raw sewage and other wastes into the reservoirs should be strictly controlled. Health protection will require that adequate sanitation facilities and safe water supplies be furnished those frequenting the area, and that adequate safety regulations, consistent with recreational usage of the water, be emphasized. The use of operating reservoirs, such as Horsetooth, for recreational purposes may be somewhat limited because of the anticipated wide fluctuations in water levels resulting from the release of stored water for irrigation purposes. Waters entering these reservoirs should be of satisfactory quality and suitable for recreational purposes. The reservoirs, as proposed for the Blue-South Platte Project, would not differ materially with respect to water quality from those being constructed on the Colorado-Big Thompson Project. All of the reservoirs proposed for the Blue-South Platte Project will be located in mountainous areas, with the lowermost (Two-Forks) being formed by a dam near the mouth of Platte Canyon above Waterton. A flood control reservoir (Chatfield) has been authorized for construction by the Corps of Engineers immediately above Littleton, Colorado. This reservoir should be similar to those described above with regard to recreational facilities. The only reservoir on the main river which may not be entirely suited to all types of recreational use is that proposed for construction in the Narrows region near Ft. Morgan, Colorado. This proposed reservoir would be subject to pollution by beet waste discharges in the Fall and would receive the accumulated wastes from other sources of pollution above the reservoir inlet. However, the concentration of pollution would be reduced by natural forces and by the large dilution afforded by this 660,000 acre-feet reservoir.

Table 33 lists the reservoirs in operation or contemplated for construction in the various projects affecting the South Platte Basin. There appears to be little chance of desirable recreational use of the streams themselves in the plains area of the South Platte Basin. The extensive use of water for irrigation in the piedmont regions precludes great recreational use. Diversion for irrigation purposes profoundly affects the stream flows. During periods of low runoff, there is insufficient water to provide for fish propagation or for any other recreational purposes.

Laboratory Data

Summary of Results

Table 34 presents a condensed summary of the laboratory data from all sampling stations along the streams during the course of the survey. The data are grouped into seasonal periods. The summer period, which corresponds roughly to the normal irrigation season, extends from May 1 to September 30 and is designated "May-September". The winter season, which corresponds roughly to the normal off-irrigation season, extends from October 1 to April 30, and is designated "October-April".

Table 33 Reservoirs in Operation or Contemplated for Various Projects Affecting South Platte Basin

Reservoir	Capacity A-f	Project	Status[1]	Est. Start Construc.	Est. Complete Construc.	Agency[2]	Stream
Green Mountain	146,888	C.B.T.[3]	1938 C	----	----	BR	--Blue River
Granby	462,900	"	U/C	----	1950	BR	--Colorado
Shadow Mountain	18,300	"	1949 C	----	----	BR	--No. Fork Colorado
*Mary's Lake	1,149	"	1949 C	----	----	BR	--Thompson
*Estes	2,855	"	1949 C	----	----	BR	--Thompson
*Carter Lake	110,000	"	P	1950	1953	BR	--Little Thompson
*Horsetooth	146,000	"	U/C	----	1952	BR	--Soldier Creek
*Flatiron	19,000	"	P	1950	1952	BR	--Cottonwood Creek
Pando	62,000	B.S.P.[4]	P	1959	1965	BR	--Eagle River
Tenmile	141,500	"	P	1951	1955	BR	--Tenmile Creek
Blue	40,000	"	P	1953	1956	BR	--Swan River
Snake	272,000	"	P	1957	1963	BR	--Snake River
*Shawnee	50,000	"	P	1959	1963	BR	--No. Fork So. Platte
*Two Forks	422,000	"	P	1952	1957[5]	BR	--South Platte
*Chatfield**	280,000	"	A	----	1966	CE	--South Platte
*Empire	77,000	"	P	1964	1967	BR	--Clear Creek
*Cherry Creek**	185,000	"	1949 C	----	----	CE	--Cherry Creek
Ruedi	100,000	"	P	1952	1956	BR	--Fryingpan River
Piney	24,300	"	P	1965	1968	BR	--Piney River
Turkshead Afterbay	1,770	"	P	1954	1956	BR	--South Platte
*Narrows	700,000	Flood Control	P	1953	1958	BR-CE	--South Platte

* On east slope of Divide feeding directly to South Platte River System.

1 - C. Construction Complete
P. Potential Reservoirs
U/C. Under Construction
A. Authorized

2 - BR. Bureau of Peclamation
CE. U.S. Army, Corps of Engineers

3 - Colorado-Big Thompson

4 - Blue-South Platte

5 - Dates when Bureau has scheduled completion of necessary irrigation works

** Primary purpose is flood control.

It may be noted that the water year begins October 1 of each year and extends to September 30 of the following year.

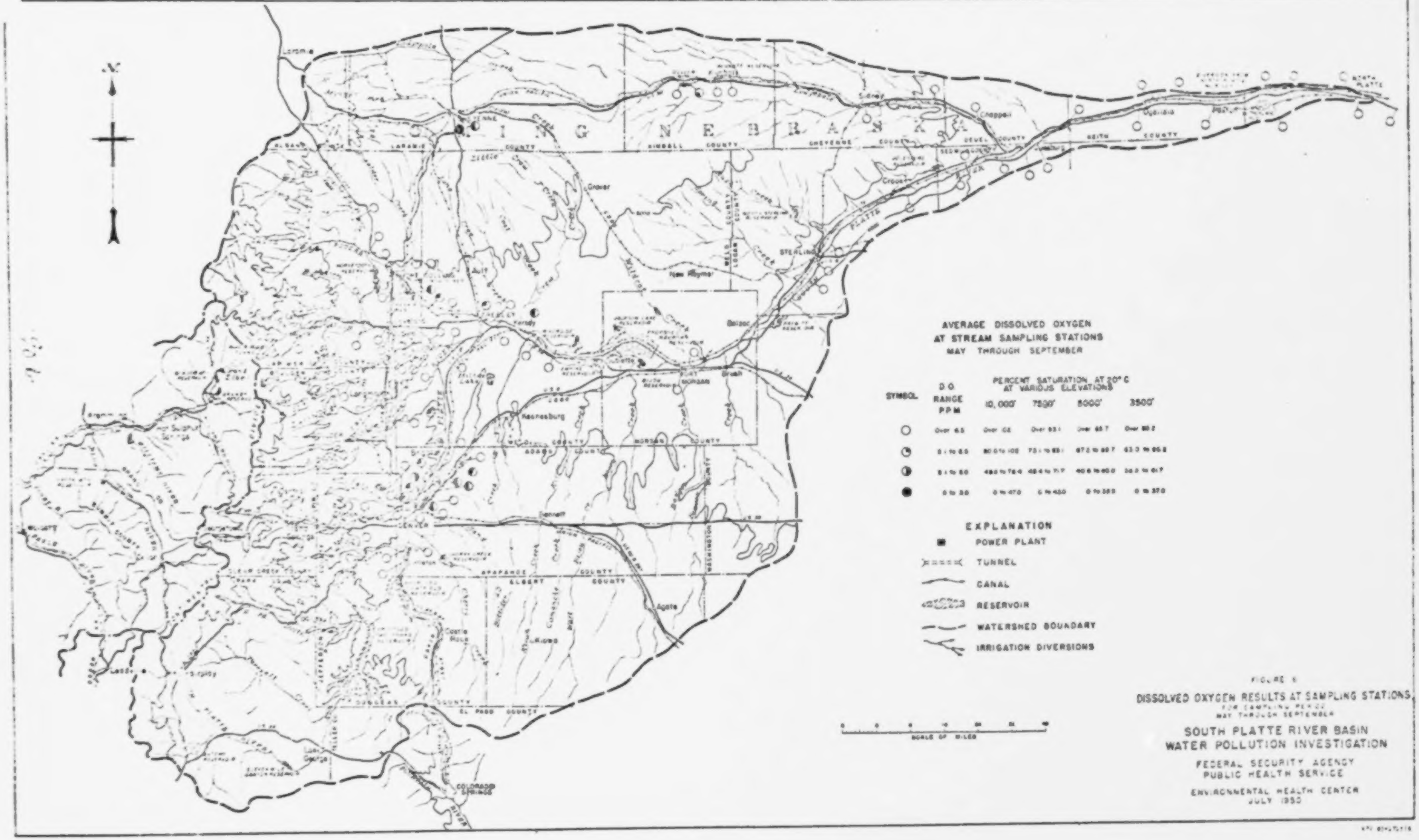
The data for each seasonal period are presented as the average value of all results obtained during the period and as the maximum and minimum values obtained during the period to show the variation. The value as shown in the table for the average of the coliform results is actually the median value which may or may not approach the arithmetic average depending upon the number of samples examined and upon the distribution of the values over the range of results. The median is the mid or central value when the results are arranged in order of magnitude. It is a much more stable measure of central tendency than the arithmetic average and is comparable to the logarithmic or geometric mean in this respect. Since the coliform results are subject to wide fluctuations, the median is a better parameter for generalizing than is the arithmetic average.

The data as shown for the determinations of alkalinity and hardness and, in some instances, for copper as well, represent the results of intermittent observations as these determinations were not made on every sample from any given sampling point.

Sampling stations along the streams were shifted to the intakes of irrigation canals during the summer period to obtain data as to the sanitary quality of the water actually entering the canals. Canals and ditches for examination were selected to give a reasonable picture of water quality to be expected above and below sources of pollution and, at the same time, give information as to the general situation over the entire basin. One canal, the Burlington-O'Brian, which receives a considerable pollution load was sampled throughout its length over most of the year and the effect of the storage of these waters in a reasonably large reservoir (Barr Lake), was observed during the irrigation season by sampling waters released to irrigation ditches from the reservoir. Results of storage were also noted on other reservoirs; Timnath and Fossil Creeks, near Ft. Collins; Oliver and Bennett Reservoirs, near Kimball, Nebraska; and the sewage lagoon below Cheyenne, Wyoming.

Detailed discussions of the laboratory results will be found in the subsequent sections of this report which deal with each sub-basin.

Average data for "Summer," "Winter" and "Beet Sugar Processing" (Oct.-Dec.) seasons are presented graphically in Figures 6-11.



SYMBOL	D.O. RANGE PPM	PERCENT SATURATION AT 20° C AT VARIOUS ELEVATIONS 10,000'	7500'	5000'	3500'
○	Over 6.5	Over 100	Over 85.1	Over 80.7	Over 80.2
◔	5.1 to 6.5	80.0 to 100	73.1 to 85.1	67.2 to 80.7	63.3 to 80.2
◑	3.1 to 5.0	48.6 to 78.4	48.4 to 71.7	40.6 to 66.0	38.2 to 61.7
●	0 to 3.0	0 to 47.0	0 to 45.0	0 to 38.5	0 to 37.0

FIGURE 6

DISSOLVED OXYGEN RESULTS AT SAMPLING STATIONS
FOR SAMPLING PERIOD
MAY THROUGH SEPTEMBER

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER
JULY 1950

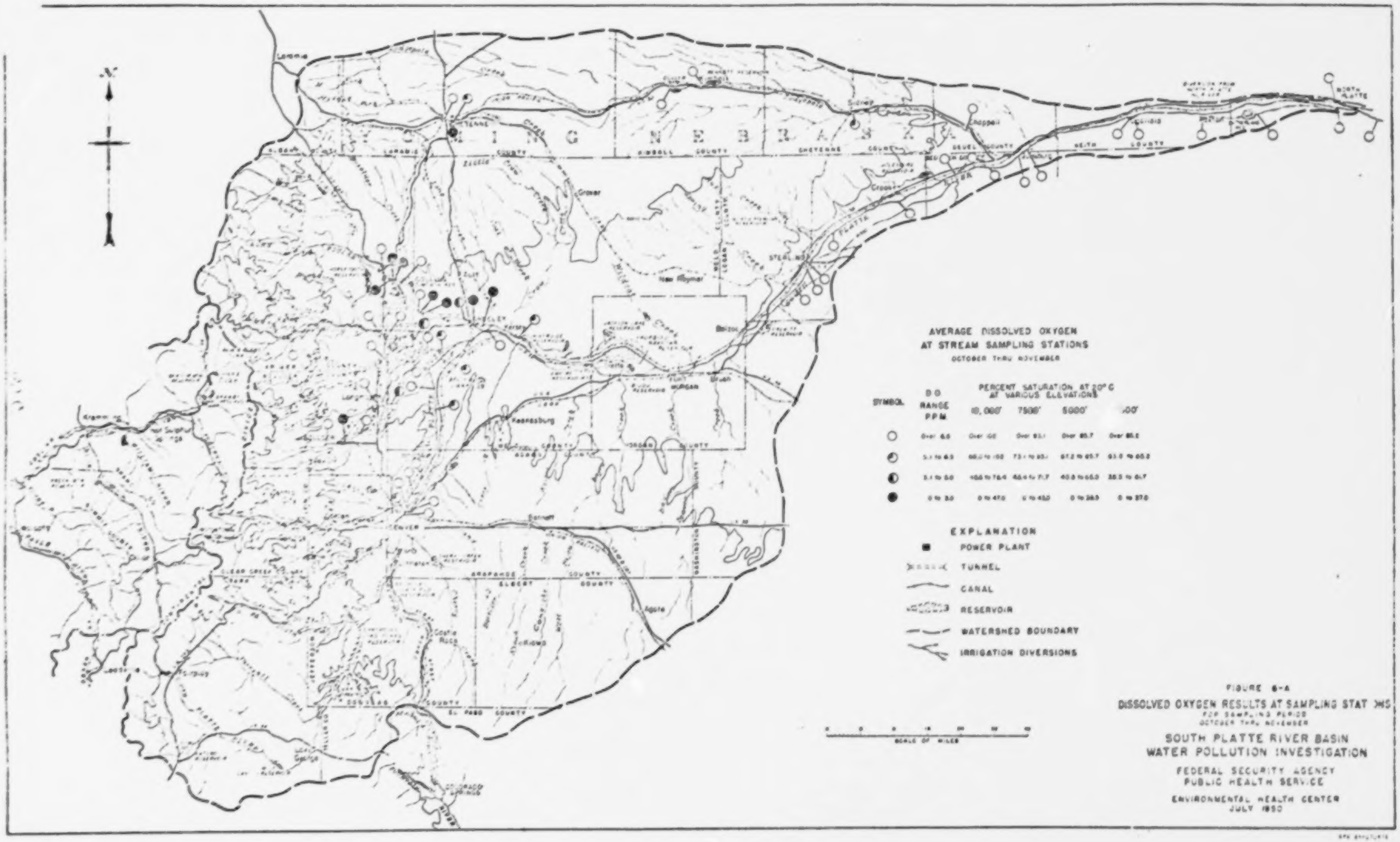


FIGURE 6-A

DISSOLVED OXYGEN RESULTS AT SAMPLING STATIONS
FOR SAMPLING PERIOD
OCTOBER THRU NOVEMBER

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER
JULY 1950

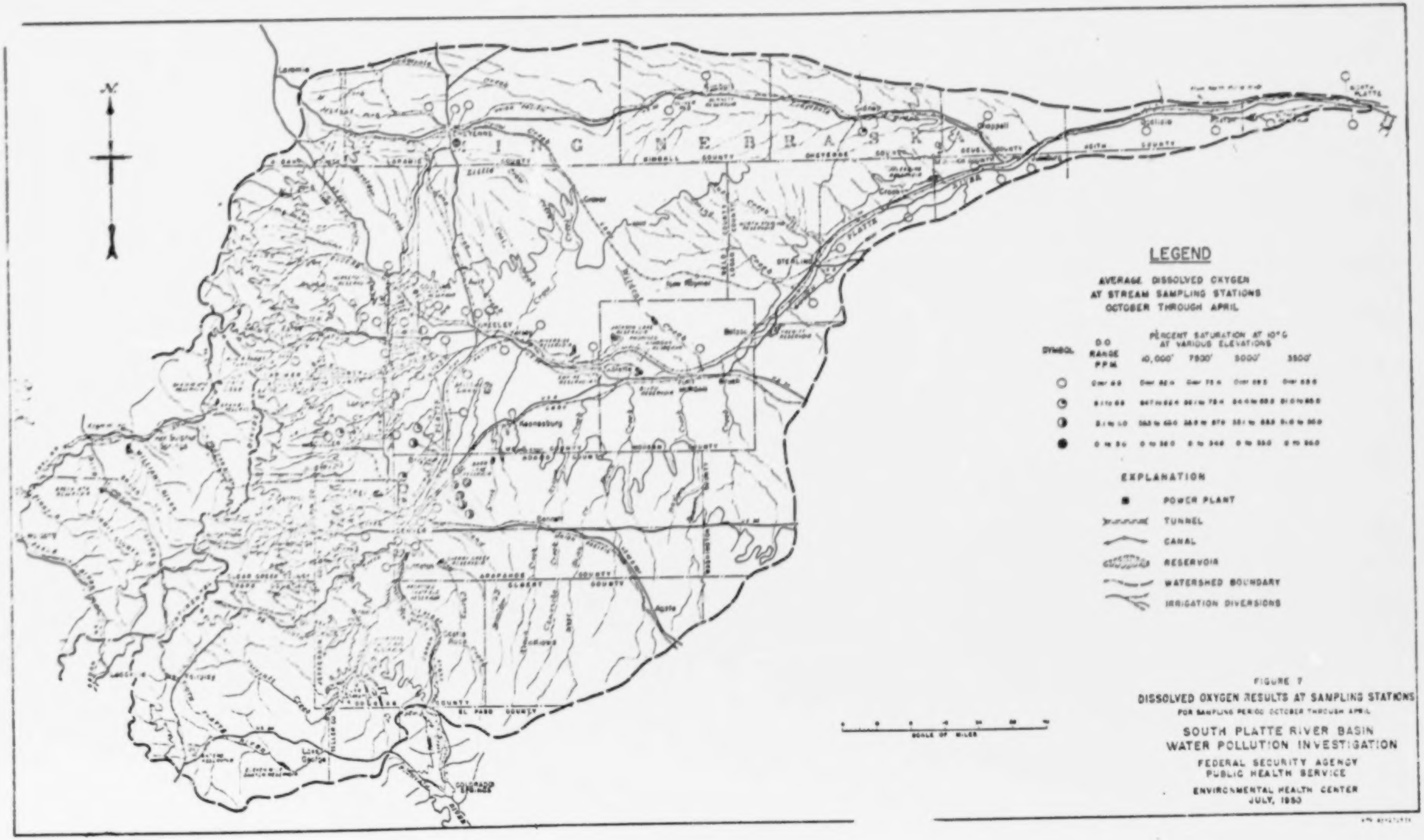


FIGURE 7

DISSOLVED OXYGEN RESULTS AT SAMPLING STATIONS

FOR SAMPLING PERIOD OCTOBER THROUGH APRIL

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER
JULY, 1950

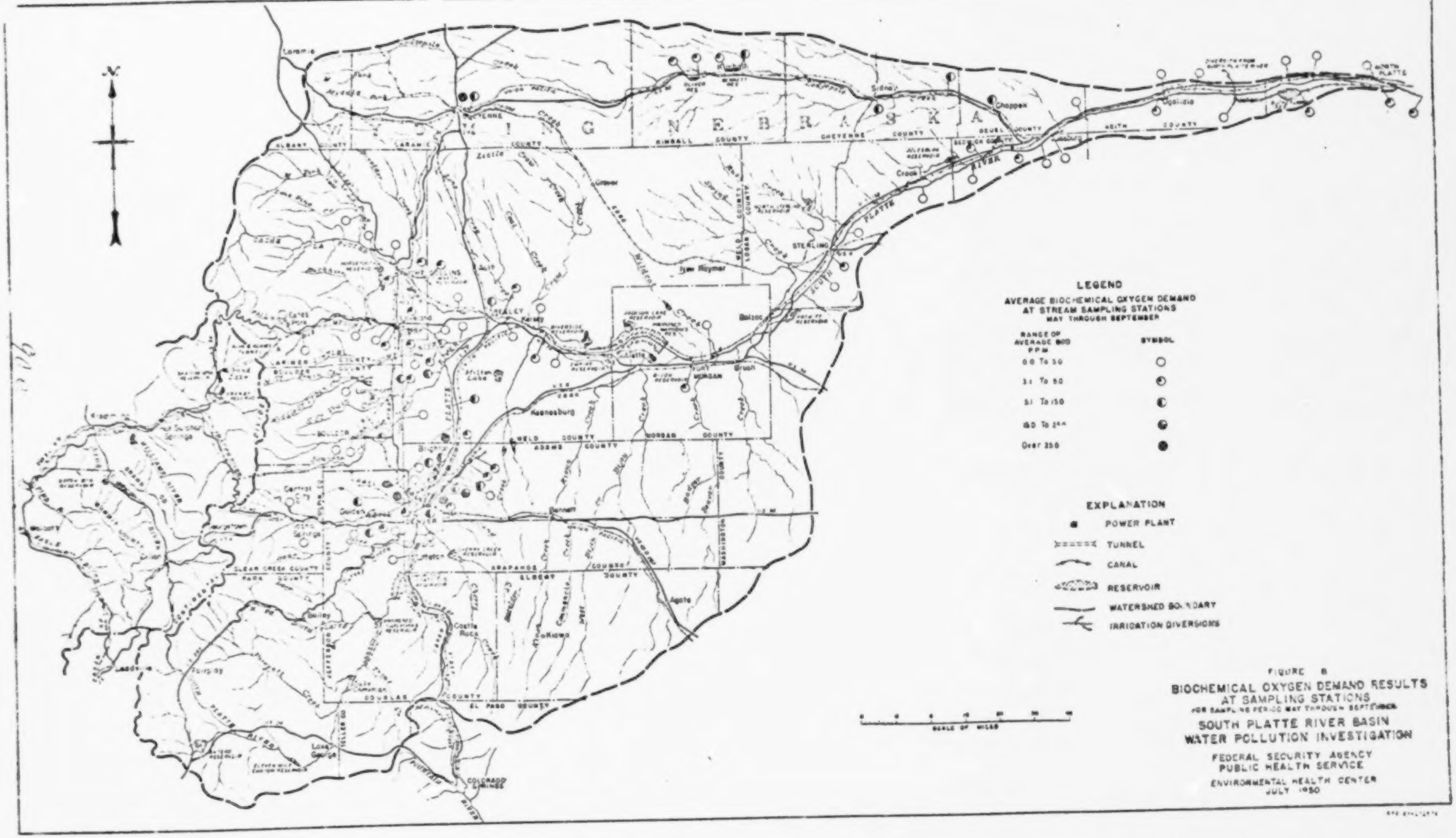


FIGURE 8

BIOCHEMICAL OXYGEN DEMAND RESULTS
AT SAMPLING STATIONS
FOR SAMPLING PERIOD MAY THROUGH SEPTEMBER

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER
JULY 1950

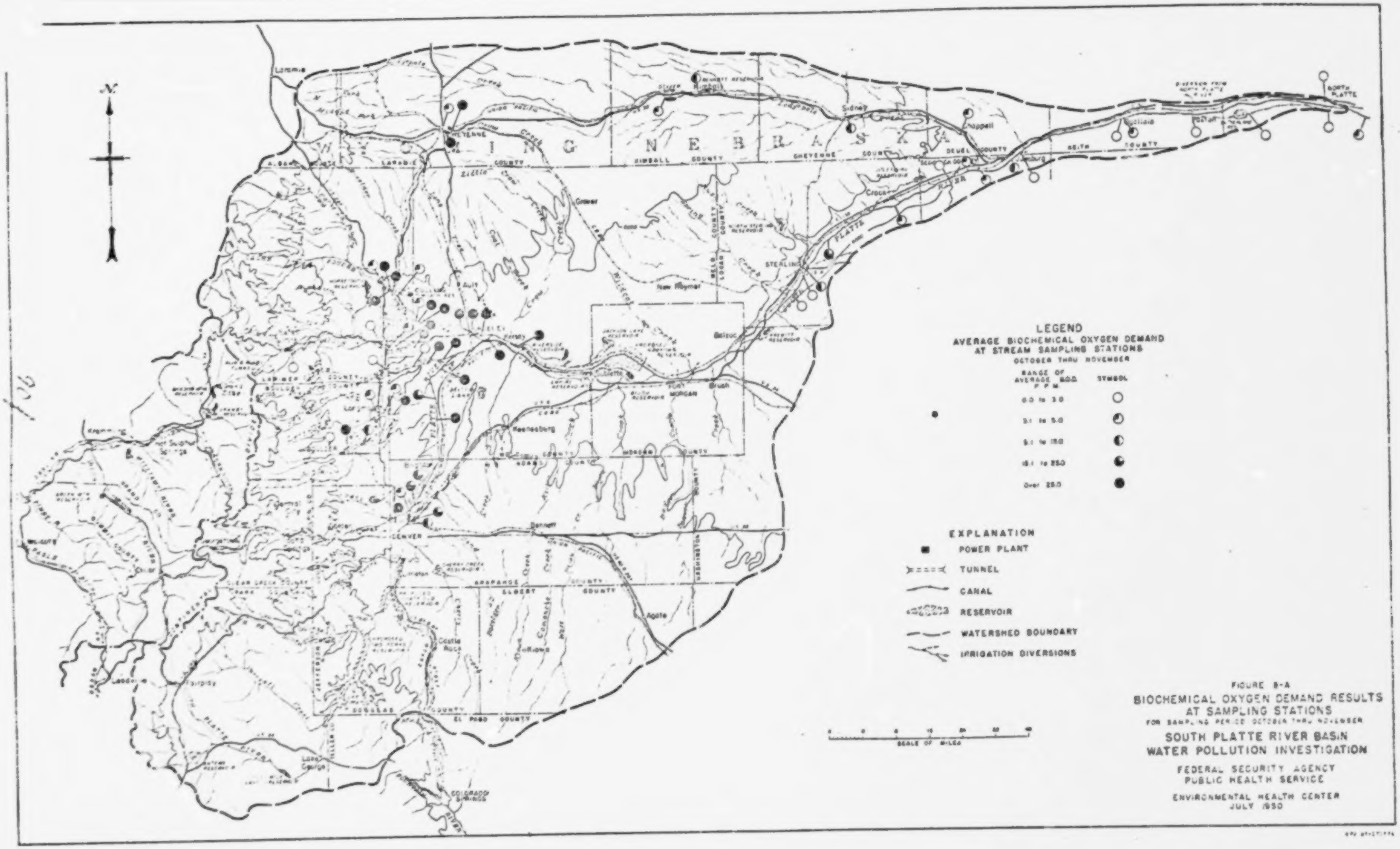


FIGURE 8-A
BIOCHEMICAL OXYGEN DEMAND RESULTS
AT SAMPLING STATIONS
FOR SAMPLING PERIOD OCTOBER THRU NOVEMBER
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

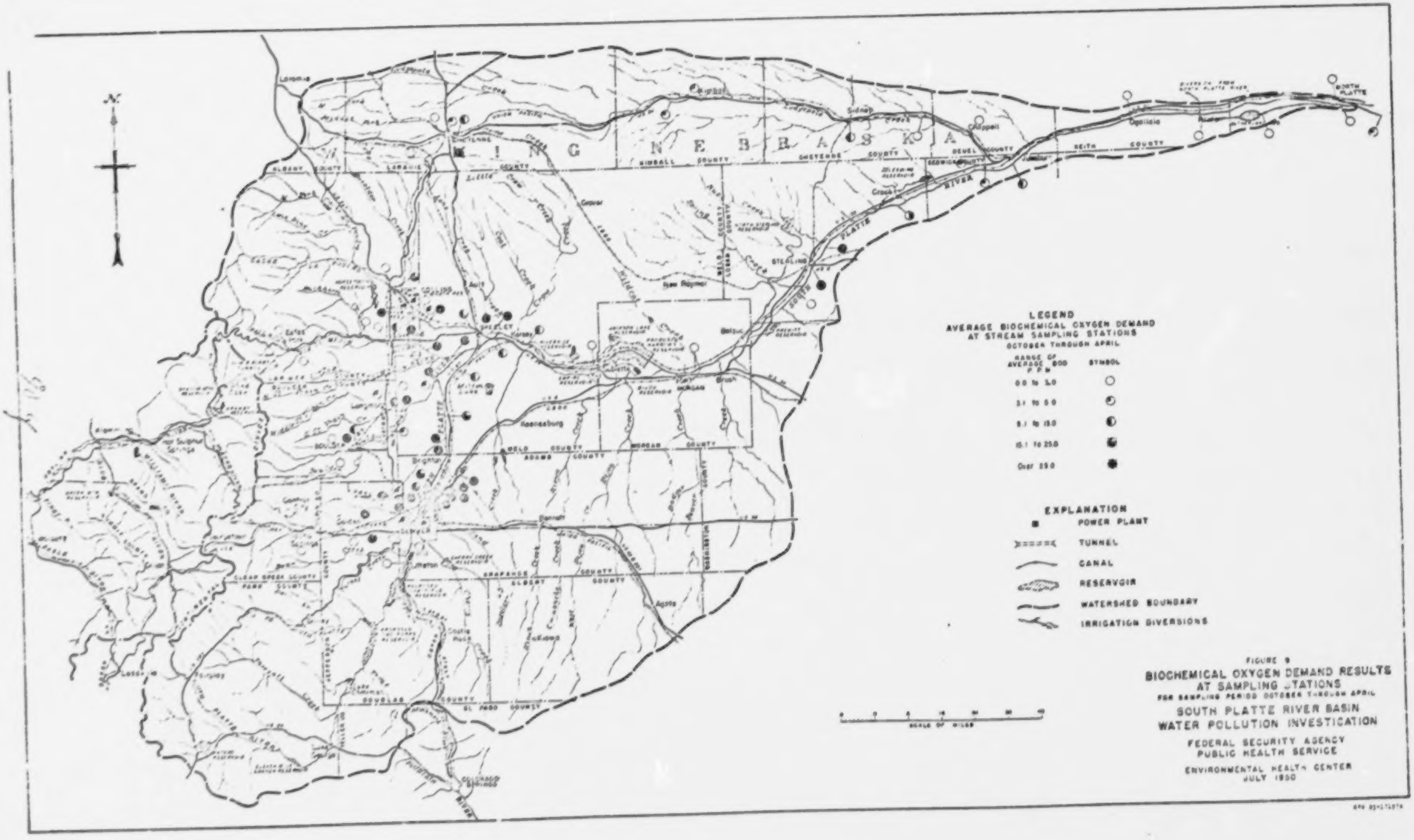


FIGURE 9

BIOCHEMICAL OXYGEN DEMAND RESULTS
AT SAMPLING STATIONS
FOR SAMPLING PERIOD OCTOBER THROUGH APRIL

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER
JULY 1950

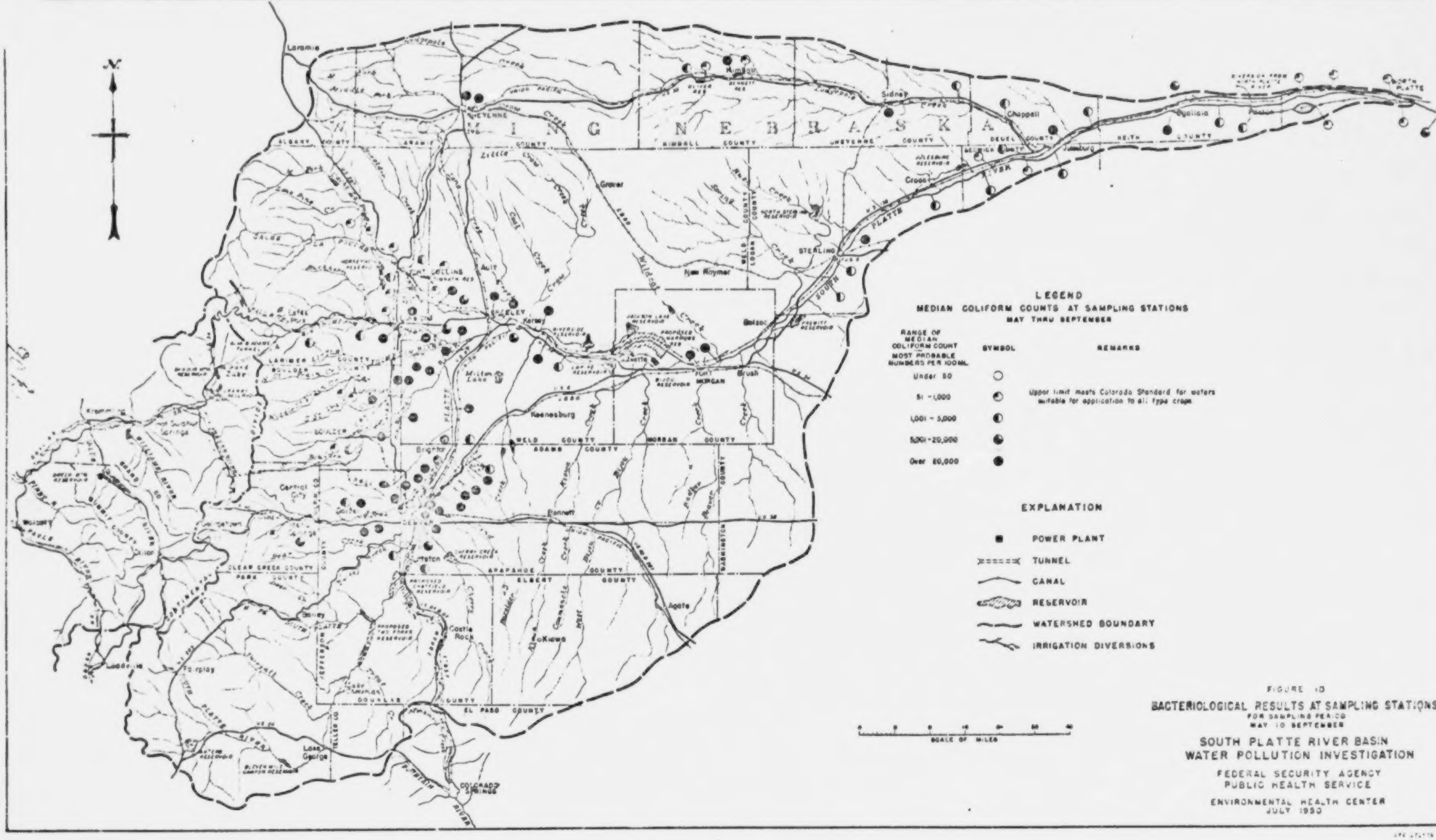


FIGURE 10

BACTERIOLOGICAL RESULTS AT SAMPLING STATIONS
FOR SAMPLING PERIOD
MAY TO SEPTEMBER

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER
JULY 1950

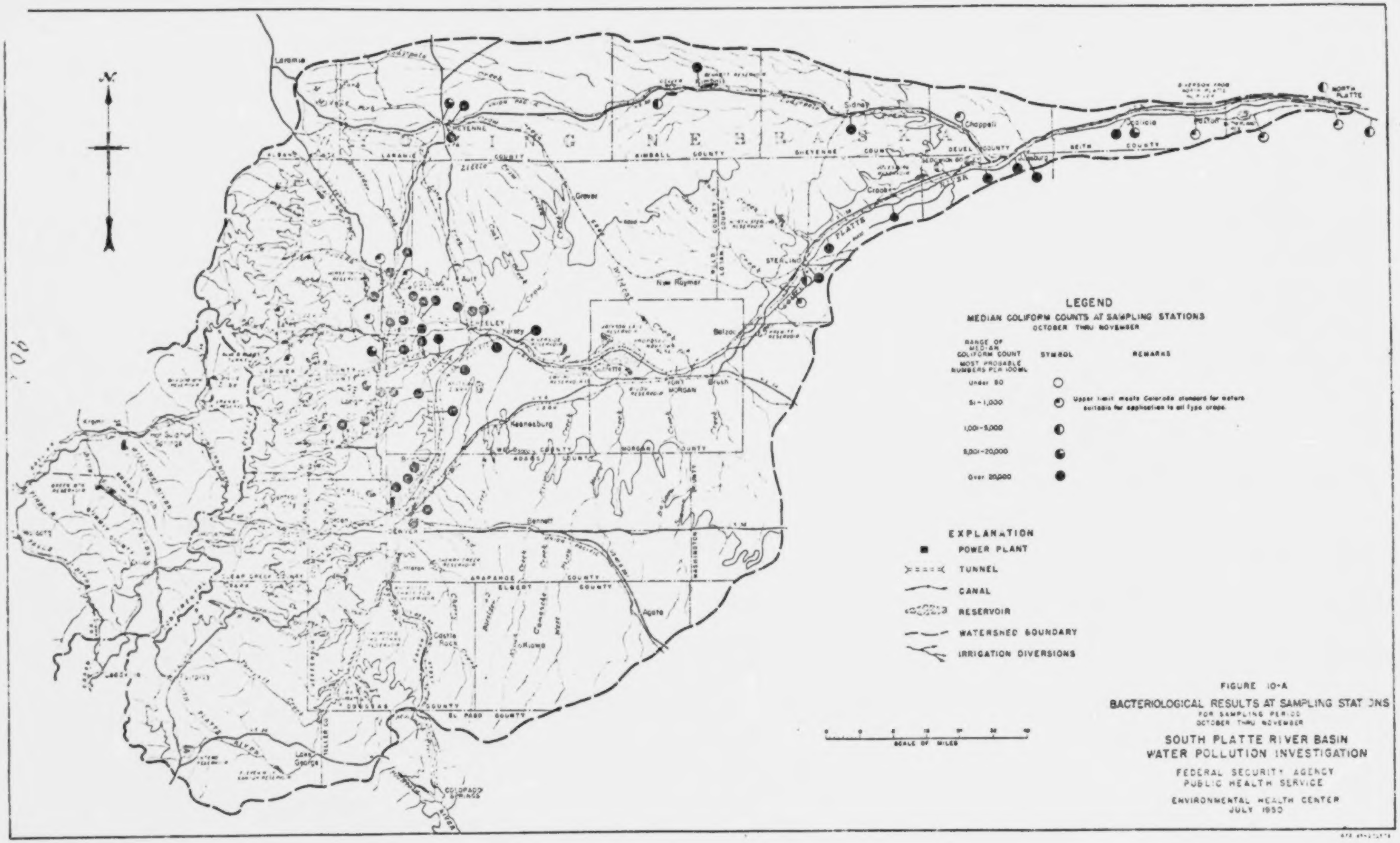


FIGURE 10-A

BACTERIOLOGICAL RESULTS AT SAMPLING STATIONS
FOR SAMPLING PERIOD
OCTOBER THRU NOVEMBER

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER
JULY 1950

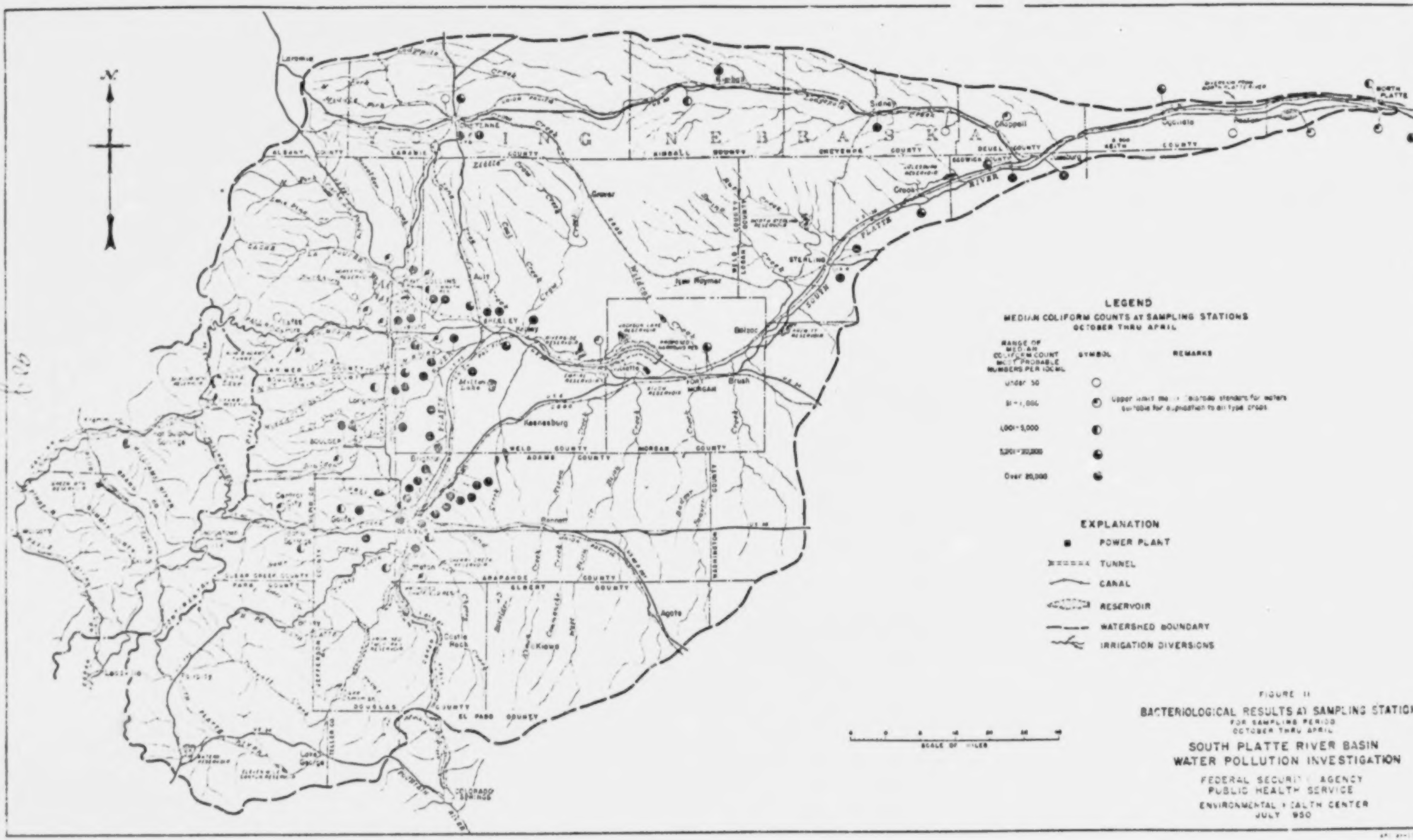


FIGURE 11

BACTERIOLOGICAL RESULTS AT SAMPLING STATIONS
FOR SAMPLING PERIOD
OCTOBER THRU APRIL

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

TABLE 34

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

LABORATORY DATA
SUMMARY OF SEASONAL RESULTS

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
							ppm.	% Sat.						
SP 314.4 Bridge at Littleton	May-Sept.	19	Avg.	824	15	-	7.9	96	1.2	-	108	184	0.08	4,300
			Max.	2430	19	-	9.	115	3.4	8.2	-	-	-	230,000
			Min.	100	11	-	6.1	92	.5	7.1	-	-	-	390
	Oct.-April	29	Avg.	103	5	-	10.8	103	1.8	-	123	148	.08	930
			Max.	290	15	-	11.7	114	5.8	8.5	148	182	.14	43,000
			Min.	40	0	-	8.9	92	.5	7.5	102	129	.04	430
SP 309.3 Evans Ave. Bridge - Denver	May-Sept.	19	Avg.	1010	15	-	8.1	97	2.1	-	136	184	.06	15,000
			Max.	2155	20	-	9.4	110	14.	8.2	-	-	-	39,000
			Min.	110	11	-	6.	74	.8	7.2	-	-	-	2,300
	Oct.-April	30	Avg.	94	6	-	11.	103	2.5	-	160	180	.11	23,000
			Max.	174	16	-	12.8	129	6.5	8.	209	227	.18	43,000
			Min.	64	0	-	9.3	91	.8	7.6	116	138	.04	2,300
SP 302.3 19th St. Gage - Denver	May-Sept.	20	Avg.	1374	17	-	7.2	90	3.2	-	156	230	.04	23,000
			Max.	6952	21	-	8.7	104	>13.	8.3	-	-	-	230,000
			Min.	126	13	-	1.	12	1.2	7.3	-	-	-	4,300
	Oct.-April	29	Avg.	121	11	-	9.1	87	4.8	-	170	191	.11	23,000
			Max.	217	20	-	11.	123	15.	8.6	206	228	.18	1,500,000
			Min.	85	4	-	6.7	73	2.6	7.5	128	138	.06	2,300

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
							ppm.	% Sat.						
SP 300.0 40th St. Bridge - Denver	May-Sept.	21	Avg.	1343	17	-	6.9	88	5.	-	156	230	0.10	23,000
			Max.	6970	21	-	8.1	103	22.	8.2	-	-	-	430,000
			Min.	136	13	-	4.3	55	.9	7.3	-	-	-	2,300
	Oct.-April	36	Avg.	136	10	-	8.9	94	7.1	-	178	191	.13	23,000
			Max.	232	17	-	10.5	122	> 29	8.1	214	207	.22	230,000
			Min.	95	4	-	4.5	49	2.3	7.2	136	184	.08	4,300
SP 299 L Below Denver Sewage Treatment Plant, Downing St. Denver	May-Sept.	10	Avg.	1157	20	-	4.9	65	56.	-	-	-	-	930
			Max.	2310	21	-	6.2	84	92	7.2	-	-	-	11,000,000
			Min.	390	18	-	3.3	43	12	7.9	-	-	-	91
	Oct.-April	28	Avg.	207^a	10	-	5.5	59	88	-	213	209	.21	4,300
			Max.	252^a	15	-	8.6	94	281	7.8	214	213	.26	4,600,000
			Min.	152^a	5	-	3.8	42	12	6.9	212	205	.05	36
SP 299 R Below Denver Sewage Treatment Plant, Downing St. Denver	May-Sept.	10	Avg.	1157	20	-	5.6	73	31	-	-	-	-	511,500
			Max.	2310	22	-	7.7	100	95	8.7	-	-	-	11,000,000
			Min.	390	18	-	2.3	32	5.8	7.3	-	-	-	9,300
	Oct.-April	28	Avg.	207^a	9	-	8	84	49	-	216	230	.19	230,000
			Max.	252^a	12	-	9.5	101	140	7.8	222	250	.28	2,400,000
			Min.	152^a	4	-	6.6	67	5.2	7.3	211	211	.05	430
SP 298.2 Gardner's Ditch Intake	May-Sept.	13	Avg.	4	18	-	5.9	75	18.	-	-	-	-	190,000
			Max.	4	22	-	7.7	92	45	7.7	-	-	-	2,400,000
			Min.	4	13	-	4.3	58	4.4	7.1	-	-	-	2,300
SP 295.5 Bridge near Welby, Colo	May	8	Avg.	854	15	132	4.4	53	43	-	192	230	.12	93,000
			Max.	2379	18	-	6.2	74	77	7.6	-	-	-	2,100,000
			Min.	80	12	-	3.1	39	13	7.4	-	-	-	15,000

a - Total stream flow for this section.

	Jan.-April	21	Avg.	131	8	-	6.2	61	31.	-	256	244	.13	43,000
			Max.	284	17	-	8.8	81	56.	7.8	278	273	.2	4,600,000
			Min.	29	3	-	3.3	41	17.	7.3	215	215	.08	9,300
SP 294.2 Headgate, Fulton Ditch	July-Sept.	5	Avg.	105	19	-	3.7	48	6.7	-	-	-	-	230,000
			Max.	201	21	-	5.1	68	>28.	-	-	-	-	430,000
			Min.	80	16	-	2.2	29	3.2	-	-	-	-	93,000
	Dec.	1	Avg.	No data	5	-	6.7	63	23.	-	-	-	-	230,000
Fulton Ditch 0.8	June-Sept.	11	Avg.	101	19	-	5.3	69	6.2	-	-	-	-	230,000
			Max.	201	22	-	7.6	96	15.	7.7	-	-	-	930,000
			Min.	29	17	-	2.8	38	1.7	7.2	-	-	-	9,300
SP 292. Headgate, Brantner Ditch	June-Sept.	10	Avg.	50	19	-	5.3	66	9.6	-	-	-	-	310,000
			Max.	61	22	-	7.3	92	22.	7.8	-	-	-	930,000
			Min.	36	17	-	3.2	30	2.6	6.9	-	-	-	7,500
SP 286.7 Bridge at Henderson	Oct.-Nov.	10	Avg.	36[b]	10	-	6.7	71	15.	-	-	-	-	43,000
			Max.	44[b]	14	-	7.9	84	34.	8.4	-	-	-	930,000
			Min.	29[b]	8	-	5.1	54	6.3	7.6	-	-	-	4,300
SP 284.0 Bridge at North city limits, Brighton, Colo.	May	2	Avg.	--	-	-	-	-	-	-	-	-	-	-
			Max.	267	18	-	3.7	45	41.	7.5	-	-	-	93,000
			Min.	182	16	-	3.8	42	32.	7.4	-	-	-	39,000
	Mar.-April	3	Avg.	183	11	-	3.4	37	38	-	236	322	.12	150,000
			Max.	245	14	-	6.1	66	>65	7.7	-	-	-	230,000
			Min.	65	8	-	1.6	18	18	7.4	-	-	-	93,000
SP 277. Bridge at Wattenberg	Nov.-Dec.	2	Avg.	No data	--	-	-	-	-	-	-	-	-	-
			Max.	---	14	-	6.2	66	31	7.9	-	-	-	930,000
			Min.	---	6	-	5.6	60	20	-	-	-	-	230,000
SP 272.2 Gage at Ft. Lupton, Colo	May-Sept.	46	Avg.	1348	19	308	5.7	12	10	-	140	211	.02	230,000
			Max.	5660	22	2700	7.	90	36	8.1	200	323	.06	4,600,000
			Min.	102	11	35	4.5	56	2.5	7.3	98	166	.01	15,000

b - No data for November.

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen ppm.	Dissolved Oxygen % Sat.	5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms * M.P.N. per 100 ml.
SP 272.2 Gage at Ft. Lupton, Colo. (Cont.)	Oct.-April	45	Avg.	172	6	120	7.6	72	16.	--	250	272	--	43,000
			Max.	294	18	290	10.7	122	69.	8.4	314	370	-	4,600,000
			Min.	37	0	25	2.8	28	1.9	7.3	207	182	--	2,300
SP 247.8 Twin Bridge, Route 60	May	9	Avg.	57	16	588	6.9	82	14.	--	174	340	0.01	43,000
			Max.	105	20	2600	8.1	92	49.	8.1	236	485	.03	210,000
			Min.	0	10	15	4.4	49	1.8	7.6	118	213	.01	2,300
	Oct.-April	50	Avg.	338	6	94	8.8	82	14.	-	246	304	.04	23,000
			Max.	517	20	180	11.2	130.	89.	8.4	287	465	.06	460,000
			Min.	197	0	20	3.9	41	1.6	7.7	207	146	.01	430
SP 247.7 Union Canal Inlet	June-Sept.	37	Avg.	105^c	20	186	7.6	97	2.1	--	171	378	.02	23,000
			Max.	135^c	24	1200	9.9	114	5.7	8.4	246	663	.06	>1,100,000
			Min.	65^c	14	20	6.	77.	1.2	7.4	77	107	.01	2,300
SP 234.5 Above junction with Cache LaPoudre -bridge on Co. road	May-Sept.	46	Avg.	2307	19	242	8.2	105.	2.7	--	190	448	.02	9,300
			Max.	13700	24	1600	10.8	144.	6.9	8.3	266	680	.04	240,000
			Min.	79	9	5	6.2	74	.6	7.4	79	142	.01	<360
	Oct.-April	50	Avg.	409	5	86	9.4	90	12.	-	225	340	.04	9,300
			Max.	584	16	170	11.5	116	71.	8.3	291	548	.07	240,000
			Min.	216	0	20	3.4	61	1.6	7.8	218	124	.02	930
SP 227.5 Riverside Canal intake	May-Sept.	46	Avg.	529^c	19	220	7.5	96	2.9	-	205	507	.02	23,000
			Max.	2860^c	24	1700	10.5	140	16.	8.3	290	782	.04	460,000
			Min.	132^c	8	10	1.9	23	.8	7.4	82	142	.01	< 360
	Mar.-April	17	Avg.	238	8	25	8.2	82	3.8	-	259	539	.03	4,300
			Max.	536	13	40	10.5	103	9.8	8.1	271	574	.06	46,000
			Min.	0	4	15	3.	31	2.2	7.7	242	483	.02	230

c - No data for June.

SP 226.9 Near bridge on Co. Road 4 mi. east of Kersey, Colo.	May	9	Avg.	389	16	309	7.3	86	6.3	-	200	459	.01	43,000
			Max.	687	20	1200	9.4	114	18.	8.1	229	604	.02	240,000
			Min.	216	9	35	4.5	56	1.9	7.7	144	315	.01	15,000
	Oct.-April	49	Avg.	432	5	66	8.9	83	5.9	-	266	360	.03	46,000
			Max.	677	16	160	10.6	122	64.	8.3	300	542	.07	2,400,000
			Min.	200	0	15	4.8	49	2.1	7.7	233	116	.01	4,300
SP 226.8 Empire Ditch intake.**	June-July	8	Avg.	No data	20	597	7.	91	3.7	-	118	248	.01	101,500
			Max.	—	24	1300	11.	149	7.7	8.6	126	267	--	460,000
			Min.	—	17	75	4.8	58	1.7	7.5	97	236	--	910
SP 217.6 Bijou Canal intake.	June-Sept.	36	Avg.	149	20	193	8.4	109	2.2	-	200	512	.02	4,300
			Max.	320	24	1500	11.9	162	12.	8.4	266	748	.04	930,000
			Min.	0	15	10	5.	61	1.1	7.5	97	175	.01	930
SP 210 Sublette, Colo. Bridge near St. Route 144	May	8	Avg.	404	16	398	8.	96	6.	-	213	459	.02	16,200
			Max.	735	20	1300	9.1	113	20.	8.2	246	536	.04	240,000
			Min.	148	14	45	7.1	83	1.4	7.7	144	315	.01	930
	Mar.-April	16	Avg.	161	9	24	10.1	103	2.1	-	249	539	.02	590
			Max.	248	16	65	11.8	120	4.2	8.2	260	581	.04	4,600
			Min.	76	6	5	8.1	90	1.	8.	241	478	.01	93
SP 183.8 Ft. Morgan, Colo. About 1 mi. below Hwy. bridge in town	May-Sept.	42	Avg.	2278d	19	680	7.7	98	3.2	-	203	507	.02	43,000
			Max.	14300d	24	13000	10.6	118	21.	8.2	245	629	.04	460,000
			Min.	45d	10	25	6.1	76	1.2	7.4	108	209	.01	2,300
SP 178.4 Lower Platte & Beaver Canal intake	June-Sept.	35	Avg.	82	20	828	7.5	96	2.6	-	199	498	.02	24,000
			Max.	270	24	12500	8.9	106	13.	8.3	239	646	.04	240,000
			Min.	0	14	25	6.	74	1.3	7.5	102	185	.01	2,300
SP 177.8 Bridge on St. Route 34, below Ft. Morgan, Colo.	March-Apr.	12	Avg.	280	9	33	9.8	99	2.1	-	248	603	.03	6,800
			Max.	402	16	55	10.7	108	4.4	8.3	262	670	.04	24,000
			Min.	195	2	6	8.4	95	1.1	8.1	238	565	.01	930

** Canal being repaired during rest of season.

d - No data for September.

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen ppm.	Dissolved Oxygen % Sat.	5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
SP 160.8 Atwood, Colo. Bridge on St. route 63	May	3	Avg.	140	15	20	8.1	91	1.8	-	222	665	.02	1,500
			Max.	152	20	25	8.4	95	2.3	8.3	260	665	.03	1,500
			Min.	126	12	15	7.6	88	1.1	8.2	185	665	.02	750
	Nov.-Dec.	9	Avg.	105	3	9	11.4	98	2.2	-	206	710	.01	230
			Max.	109	8	25	11.8	102	3.4	8.2	280	745	.02	11,000
			Min.	102	0	2	10.9	94	1.3	8.0	164	662	.01	43
SP 155.4 Cole Extension Ditch intake.	July-Sept.	8	Avg.	22	21	30	10.2	130	3.7	-	196	394	.02	1,215
			Max.	71	26	75	13.3	179	6.8	8.4	206	513	.05	4,600
			Min.	0	14	8	7.2	96	2.1	8.1	184	323	.01	230
SP 155.1 Sterling Canal #1 intake	Oct.	7	Avg.	49	12	33	9.7	100	2.8	-	228	529	.01	4,600
			Max.	88	14	50	10.6	120	4.	8.3	240	551	.02	46,000
			Min.	28	9	5	9.2	97	1.6	7.8	193	513	.01	930
SP 153 Sterling, Colo. Bridge on U.S. Hwy. 6	Nov.-Dec.	9	Avg.	128	4	80	9.8	85	66.	-	309	721	.07	2,300,000
			Max.	134	8	150	12.	97	240.	8.5	397	732	.1	11,000,000
			Min.	121	0	10	7.7	74	7.7	7.9	179	704	.01	300
SP 144.5 Ford, Colo. Bridge on St. Hwy. east of town	May	4	Avg.	166	15	13	8.1	91	2.3	-	241	716	.02	57,000
			Max.	215	21	15	8.6	96	2.8	8.2	264	846	.03	240,000
			Min.	130	12	10	7.6	88	1.9	8.2	205	646	.01	9,300
	Oct.-Dec.	16	Avg.	161	7	43	7.1	71	30.	-	231	601	.02	930,000
			Max.	190	18	120	10.2	125	58	8.4	320	718	.04	4,300,000
			Min.	114	0	3	4.5	40	2.8	7.6	176	466	.01	9,300

SP 124.1 Crook, Colo. Bridge on St. Hwy. 25	May	4	Avg.	99	15	40	7.6	84	2.7	-	224	713	.03	4,350
			Max.	253	20	55	8.9	94	4.	8.3	262	846	.06	9,300
			Min.	31	12	20	5.5	61	1.5	8.3	164	656	.02	930
	Oct.- Dec.	14	Avg.	235	5	39	9.4	84	7.7	-	213	614	.01	12,200
			Max.	258	14	65	13.5	107	14.	8.3	305	760	.03	460,000
			Min.	188	0	20	6.5	51	1.9	7.9	154	418	.01	910
SP 105.6 Sedgwick, Colo. Bridge on St. Hwy. 59	May	4	Avg.	150	16	15	8.7	99	2.	-	222	691	.02	1,215
			Max.	353	20	20	9.3	105	2.6	8.3	243	761	.03	4,300
			Min.	54	14	9	7.4	92	1.3	8.3	192	646	.01	930
SP 103.6 Peterson Canal intake	July- Sept.	9	Avg.	68	24	17	7.5	100	3.3	-	199	488	.02	930
			Max.	103	28	45	8.4	117	4.7	8.4	230	561	.04	24,000
			Min.	20	16	4	6.5	80	1.7	8.2	175	399	.01	430
	Oct.	7	Avg.	20	14	16	13.1	143	2.3	-	226	554	.02	2,400
			Max.	20	17	25	17.7	189	4.2	8.4	289	637	.04	46,000
			Min.	20	12	10	9.	102	.7	8.2	183	503	.01	430
SP 98.1 Ovid, Colo. Bridge on St. Hwy. 23	May	4	Avg.	172	16	9	9.	103	3.1	-	177	731	.03	680
			Max.	370	16	10	9.7	111	6.3	8.3	193	846	.03	2,300
			Min.	79	15	8	8.2	94	1.3	8.3	162	617	.02	150
	Oct.- Dec.	14	Avg.	352	6	41	10.9	97	3.6	-	206	596	.02	24,000
			Max.	438	14	80	12.3	105	4.8	8.3	247	704	.05	110,000
			Min.	248	0	20	9.	86	2.3	7.9	146	484	.01	4,300
SP 90.0 Julesburg, Colo. Bridge on St. Rt. 51	May	4	Avg.	234	16	20	8.7	100	2.5	-	197	722	.03	2,900
			Max.	475	18	30	9.5	106	3.7	8.3	198	846	.04	4,300
			Min.	146	15	8	8.1	97	1.4	8.2	196	598	.02	430
	Oct.- Dec.	13	Avg.	376	6	44	9.4	84	9.5	-	197	558	.03	430,000
			Max.	497	16	55	11.6	96	17.	8.3	296	732	.06	930,000
			Min.	278	0	30	7.5	75	3.1	8.	137	342	.01	4,300

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms * M.P.N. per 100 ml.
							ppm.	% Sat.						
SP 84.5 Western Canal Intake	July-Sept.	9	Avg.	129	25	45	8.3	112	2.5	-	211	388	.02	43,000
			Max.	267	28	140	10.8	149	3.1	8.4	246	475	.05	110,000
			Min.	66	17	10	7.	96	1.7	8.3	128	276	.01	15,000
	Oct.	4	Avg.	95	15	63	8.7	98	2.3	-	225	480	.02	66,000
			Max.	122	18	100	9.	107	>7.5	8.4	234	513	.03	460,000
			Min.	76	12	25	8.1	85	2.2	7.3	216	447	.01	23,000
SP 77.2 Big Springs, Nebr. Bridge on road south of town.	May	4	Avg.	222	18	10	8.9	106	2.3	-	218	727	.02	3,200
			Max.	451	20	15	9.3	112	3.5	8.3	230	846	.02	4,300
			Min.	93	16	8	8.4	98	1.8	8.3	206	608	.02	930
SP 58.0 Hollingsworth Canal Inlet, Ogallala, Nebr.	July-Sept.	7	Avg.	7.1	23	113	8.5	110	4.6	-	189	473	.02	33,000
			Max.	12.2	28	250	10.2	122	7.3	8.4	218	532	.05	110,000
			Min.	0.4	14	3	7.3	101	2.9	8.2	155	390	.01	2,100
	Oct.	4	Avg.	22	15	25	10.	110	3.8	-	205	472	.02	8,400
			Max.	23	18	30	10.3	113	5.4	8.4	225	484	.03	46,000
			Min.	20	11	20	9.8	105	2.8	8.3	194	456	.01	4,300
SP 57.2 Ogallala, Nebr. Bridge on St. Hwy. south of town.	May	4	Avg.	273	19	43	8.6	103	2.6	-	245	542	.03	7,650
			Max.	334	23	90	9.7	114	3.9	8.4	322	657	.05	46,000
			Min.	235	16	4	8.	91	2.	8.1	201	447	.02	150
	Dec.	4	Avg.	298	2	6	14.2	115	3.1	-	239	690	.01	16,575
			Max.	381	6	10	15.9	141	3.9	8.4	330	760	.01	24,000
			Min.	123	0	2	12.1	94	2.3	8.1	182	620	.01	4,300

SP 49.2 Roscoe, Nebr. Bridge on Co. road s. of town	May	4	Avg.	328	18	35	8.7	104	2.4	–	211	591	.02	2,300
			Max.	411	20	70	9.2	107	2.8	8.4	219	614	.03	24,000
			Min.	296	16	2	8.2	101	1.8	8.3	205	570	.01	430
SP 23.8 Sutherland, Nebr. Bridge on Co. road south of town	May	4	Avg.	130	16	5	8.9	101	2.	–	224	313	.02	360
			Max.	179	17	10	9.1	105	2.7	8.1	225	359	.04	3,900
			Min.	97	13	1	8.8	95	1.3	8.	222	257	.02	110
SP 17.2 Hershey, Nebr. Bridge on Co. road south of town	May	4	Avg.	182	16	15	9.1	104	1.4	–	218	344	.04	161
			Max.	242	19	25	9.5	111	2.6	8.3	224	377	.10	2,300
			Min.	139	14	1	8.7	99	1.2	8.2	214	304	.01	91
SP 4. Bridge south of North Platte, Nebr.	May- Sept.	6	Avg.	298	15	19	9.	100	1.7	–	214	353	.02	230
			Max.	336	17	45	9.4	106	3.	8.3	222	390	.04	11,000
			Min.	236	14	1	8.6	97	1.2	8.2	206	295	.01	93
	Oct.- Dec.	8	Avg.	232	9	16	11.	101	1.2	–	222	320	.02	1,500
			Max.	498	17	45	13.8	122	1.6	8.4	242	352	.04	11,000
			Min.	135	0	4	8.6	94	.6	8.1	205	276	.01	43
Diversion from North Platte River - Power Canal at Paxton, Nebr.	May- Sept.	6	Avg.	1285	17	20	9.	104	2.7	–	187	405	.03	1,315
			Max.	1500	19	45	9.4	109	3.8	8.4	212	560	.07	4,300
			Min.	1140	15	1	8.7	96	1.5	8.2	154	152	.01	23
	Oct.- Dec.	6	Avg.	1398	8	7	11.1	103	2.5	–	203	199	.01	43
			Max.	1480	17	10	13.2	106	3.4	8.4	216	249	.03	430
			Min.	1030	2	6	8.8	99	2.	8.	187	133	.01	9
Sutherland Power Reservoir Outlet	July- Sept.	12	Avg.	1212	22	17	8.1	102	3.5	–	174	263	.02	93
			Max.	1290	26	25	9.1	108	5.9	8.6	182	323	.04	4,600
			Min.	1110	15	4	7.2	97	2.1	8.3	158	133	.01	23
	Oct.	3	Avg.	750	15	27	8.	79	2.6	–	169	171	.02	430
			Max.	1270	16	30	9.	101	3.	8.4	206	209	.02	11,000
			Min.	1	12	20	6.4	66	2.3	7.9	179	143	.01	230

SUMMARY OF SEASONAL RESULTS (Continued)

(1) Sampling Point Mileage from Mouth	(2) Sampling period	(3) No. of samples	(4) Result	(5) Stream Flow c.f.s.	(6) Temp. °C.	(7) Turbidity, ppm.	(8) Dissolved Oxygen ppm.	(8) Dissolved Oxygen % Sat.	(9) 5-Day BOD ppm.	(10) pH	(11) Alkalinity, ppm.	(12) Hardness, ppm.	(13) Copper, ppm.	(14) Coliforms* M.P.N. per 100 ml.
SP 3.5 Power Plant Tailrace outlet	May-Sept.	16	Avg.	1057	20	29	8.4	103	4.	–	164	275	.03	240
			Max.	1320	27	55	10.1	113	5.3	8.5	194	370	.05	11,000
			Min.	380	13	2	7.1	97	2.7	7.9	123	162	.01	36
	Oct.-Dec.	8	Avg.	1007	9	15	10.6	98	2.8	–	197	239	.02	113
			Max.	1800	16	45	13.4	114	3.6	8.4	227	332	.04	930
			Min.	40	2	8	6.1	65	1.9	7.9	180	143	.01	15
Platte River – Supply Canal Intake, below junction of North & South Platte Rivers.	July-Sept.	10	Avg.	1859	20	8	7.7	94	3.3	–	177	185	.03	10,150
			Max.	2040	24	20	9.2	101	6.1	8.4	200	228	.04	110,000
			Min.	1368	10	1	6.3	81	1.6	8.1	112	162	.01	2,400
	Oct.-Dec.	8	Avg.	1744	7	17	10.8	98	3.5	–	198	245	.02	6,950
			Max.	2036	16	25	13.2	101	5.7	8.3	224	318	.05	43,000
			Min.	1483	0	10	8.4	93	2.2	8.2	177	162	.01	2,300
Be 0.75 Gaging station near mouth	May-Sept.	19	Avg.	182e	15	–	8.7	105	2.2	–	228	230	.1	4,300
			Max.	992e	19	–	12.	143	6.1	8.4	–	–	–	75,000
			Min.	5e	11	–	5.9	73	1.	7.5	–	–	–	430
	Oct.-Apr.	20	Avg.	9.5	7	–	11.5	117	2.9	–	248	259	.1	1,500
			Max.	12	16	–	12.8	158	>7.5	8.4	258	276	.14	23,000
			Min.	8	2	–	9.	87	.3	7.3	226	249	.08	93
Ch 1. Larimer St. bridge Denver, Colo.	May-June	9	Avg.	82	15	–	7.3	87	8.6	–	168	230	–	23,000
			Max.	426	20	–	9.	107	51	8.6	–	–	–	230,000
			Min.	5.8	11	–	4.2	55	1.6	7.8	–	–	–	4,300
	Mar.-April	9	Avg.	12.7	10	–	9.9	106	4.2	–	169	190	.18	4,300
			Max.	27	16	–	11.2	115	13.	8.6	206	253	.26	93,000
			Min.	5.4	5	–	8.1	93	1.4	7.9	140	138	.14	2,300

e – Flows for July, August, and September estimated.

Barr Lake, West Outlet, Speer Canal	June-Sept.	29	Avg.	60	21	21	7.7	102	4.	-	155	221	.03	1,215
			Max.	75	24	50	9.2	130	>7.8	9.4	180	357	.05	24,000
			Min.	0	16	5	5.	67	1.6	7.7	138	175	.01	230
Barr Lake, East Outlet, Neres Canal	June-Sept.	31	Avg.	58	21	138	7.5	99	5.6	-	141	195	.02	4,300
			Max.	89	24	2300	11.9	162	16.	9.4	177	255	.05	1,100,000
			Min.	0	14	10	4.6	59	2.1	7.4	69	87	.01	430
B-O'B 14. Barr Lake Inlet	May-Sept.	18	Avg.	139	20	106	4.2	62	4.3	-	120	184	.02	93,000
			Max.	250	23	220	6.3	82	17	8.	149	204	.04	930,000
			Min.	0	15	20	1.1	14	2.2	7.2	88	157	.01	2,300
	Dec. April	10	Avg.	118	6	-	.8	10	75	-	-	-	.15	430,000
			Max.	170	16	-	6.	74	109	7.8	-	-	.16	4,600,000
			Min.	0	1	-	0	0	35	7.2	-	-	.14	23,000
B-O'B 10.5	Jan.-Feb	5	Avg.	131	4	-	1.1	10	73	-	-	-	.13	430,000
			Max.	164	6	-	2.	19	97	7.4			.16	11,000,000
			Min.	66	3	-	0	0	54	7.3			.1	9,300
B-O'B 8.7	May-Sept.	5	Avg.	272	17	-	4.3	53	12	-	-	-	-	93,000
			Max.	710	19	-	6.9	88	28	7.5	-	-	-	4,600,000
			Min.	67	15	-	1.	12	2.1	7.	-	-	-	2,300
	Jan.-April	6	Avg.	140	6	-	2.6	22	46	-	-	-	.17	93,000
			Max.	170	12	-	4.4	39	66	7.6	-	-	.20	4,600,000
			Min.	72	3	-	.8	9	29	7.3	-	-	.12	43,000
B-O'B 4.8	June-Sept.	3	Avg.	196	18	-	4.9	62	2.6	-	-	-	-	43,000
			Max.	360	19	-	7.1	93	3.	7.9	-	-	-	4,600,000
			Min.	68	16	-	1.4	18	2.3	7.9	-	-	-	23,000
	Jan.-March	6	Avg.	132	6	-	3.4	32	39	-	-	-	.16	190,000
			Max.	185	10	-	4.8	43	47	7.5	-	-	.18	4,600,000
			Min.	75	3	-	1.3	14	29	7.4	-	-	.14	43,000

SUMMARY OF SEASONAL RESULTS (Continued)

(1) Sampling Point Mileage from Mouth	(2) Sampling period	(3) No. of samples	(4) Result	(5) Stream Flow c.f.s.	(6) Temp. °C.	(7) Turbidity, ppm.	(8) Dissolved Oxygen ppm.	Dissolved Oxygen % Sat.	(9) 5-Day BOD ppm.	(10) pH	(11) Alkalinity, ppm.	(12) Hardness, ppm.	(13) Copper, ppm.	(14) Coliforms * M.P.N. per 100 ml.
B-O'B 3.0	Jan.- April	8	Avg.	131	8	-	4.8	48	41.	-	-	-	0.2	43,000
			Max.	211	13	-	6.1	54	65.	7.6	-	-	.24	2,400,000
			Min.	48	3	-	4.3	43	24.	7.4	-	-	.14	9,300
B-O'B 0.5	May- Sept.	26	Avg.	206	17	-	6.1	76	21.	-	-	-	-	59,000
			Max.	570	22	-	8.	101	100.	8.	-	-	-	11,000,000
			Min.	28	12	-	1.9	26	.8	7.2	-	-	-	7,500
	Dec.- April	36	Avg.	149	9	-	5.6	60	67.	-	185	199	.16	41,000
			Max.	250	17	-	7.	73	174.	7.8	208	230	.26	11,000,000
			Min.	28	0	-	3.7	45	22.	7.3	148	161	.02	30
Cl 38.5 Bridge at western edge of Idaho Springs	May- Sept.	14	Avg.	520	13	-	8.4	102	.8	-	-	-	-	230
			Max.	1470	15	-	9.1	112	1.2	7.7	-	-	-	430,000
			Min.	105	10	-	7.9	95	.3	6.8	-	-	-	36
	Dec.- Apr.	6	Avg.	34	6	-	10.1	100	1.	-	-	-	-	91
			Max.	45	10	-	10.9	107	1.9	7.4	48	55	-	2,300
			Min.	28	0	-	9.	93	.7	6.9	48	55	-	< 3
Cl 33.2 Crossing on Hwy. U.S. 40 below Idaho Springs	May- Sept.	14	Avg.	520	13	-	8.4	103	.7	-	-	-	-	9,300
			Max.	1470	16	-	9.	108	1.3	7.7	-	-	-	23,000
			Min.	105	10	-	7.9	98	.3	6.5	-	-	-	1,500
	Dec.- April	6	Avg.	41	5	-	10.3	103	1.3	-	-	-	-	3,300
			Max.	55	10	-	11.1	109	1.7	7.4	-	-	-	9,300
			Min.	33	0	-	9.5	94	.8	7.2	-	-	-	930

Cl 18.0 Bridge at Golden, Colo.	May-Sept.	16	Avg.	985	15	-	8.6	104	.8	-	-	-	-	2,300
			Max.	2675	18	-	9.3	114	1.5	7.6	-	-	-	23,000
			Min.	124	11	-	7.8	98	.3	6.8	-	-	-	430
	Dec.-April	6	Avg.	47	7	-	10.7	106	1.6	-	-	-	-	1,615
			Max.	55	14	-	11.7	109	2.3	7.5	-	-	-	4,300
			Min.	40	2	-	9.2	102	1.1	7.2	-	-	-	< 3
Cl 17.5L Below Golden Sewer Outfall at Wanamaker Ditch Intake	May-Sept.	17	Avg.	11	15	-	7.9	97	5.3	-	-	-	-	93,000
			Max.	14	19	-	9.1	110	22.	7.4	-	-	.08	930,000
			Min.	7	11	-	5.5	67	1.	6.6	-	-	-	9,300
	Dec.-April	12	Avg.	12.5	5	-	9.6	89	58.	-	-	-	.12	1,500,000
			Max.	21	16	-	10.9	106	238	7.6	-	-	.14	11,000,000
			Min.	8	0	-	5.5	68	12.4	7.2	-	-	.10	93,000
Cl 17.5R Below Coor's Brewery at Lee, Stewart, & Eakins Ditch Intake	May-Sept.	16	Avg.	21	16	-	7.9	98	6.8	-	-	-	-	93,000
			Max.	121	19	-	8.9	109	>15.	7.9	-	-	.12	930,000
			Min.	0	12	-	6.4	84	1.9	6.8	-	-	-	2,300
	Dec.-April	12	Avg.	29	5	-	9.5	88	36.	-	-	-	.08	590,000
			Max.	47	16	-	11.	103	67.	7.7	76	115	.11	2,400,000
			Min.	4	0	-	5.5	69	13.	7.2	-	-	.04	43,000
Cl 16.1 Rocky Mt. Ditch Intake	June-Sept.	13	Avg.	52	16	-	7.1	88	3.8	-	-	-	.01	150,000
			Max.	190	21	-	8.9	108	6.2	7.5	-	-	-	430,000
			Min.	9	13	-	5.2	64	1.6	6.9	-	-	-	9,300
Cl 3.4 Lower Clear Creek & Colo. Agri. Canal intake.	June-Sept.	12	Avg.	20.5	17	-	7.9	98	2.8	-	-	-	-	43,000
			Max.	30	20	-	8.5	106	4.9	8.	-	-	-	930,000
			Min.	6	13	-	7.2	89	1.2	7.	-	-	-	9,300
Cl 0.8 Crossing on Co. Road near routh	May-June	3	Avg.	41[f]	15	-	9.5	116	2.8	-	-	-	-	39,000
			Max.	74[f]	17	-	10.9	136	2.8	-	-	-	-	93,000
			Min.	8[f]	14	-	8.	96	2.7	-	-	-	-	9,300

f - No data for June.

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
							ppm.	% Sat.						
Cl 0.8 Crossing on Co. Rd. near mouth (Cont.)	Oct.-April	9	Avg.	21^{g}	9	-	9.	93	4.5	-	-	-	-	23,000
			Max.	37^{g}	14	-	11.6	122	13.	8.3	200	230	-	2,400,000
			Min.	8^{g}	5	-	2.6	29	2.7	7.7	-	-	-	930
SV 38.9 Supply Canal Intake below Lyons, Colo.	June	2	Max.	60	14	25	9.3	107	.7	7.1	24	38	-	75
			Min.	0	12	2	9.2	104	.4	7.1	17	9	-	43
SV 38.4 Highland & Rough & Ready Canal Intake	June-Sept.	11	Avg.	105	16	6	8.5	103	1.4	-	22	15	.06	430
			Max.	285	22	20	9.3	109	2.4	7.3	29	38	.09	11,000
			Min.	15.7	12	1	7.4	96	.7	7.	14	6	.04	23
SV 29.5 Bridge on Co. Rd. 1½ m. west of Longmont, Colo.	Nov-April	23	Avg.	3.4	6	12	11.6	109	3.5	-	208	388	.03	4,300
			Max.	5	17	20	15.8	184	8.	8.4	255	517	.08	430,000
			Min.	2	0	2	9.2	86	1.6	7.6	142	283	.01	150
SV 27.5 Bridge on U.S. Hwy 87, south of Longmont, Colo.	Aug.-Sept.	4	Avg.	3.5	19	18	8.3	107	4.3	-	174	270	.03	33,000
			Max.	3.5	22	25	9.2	116	5.9	8.	181	294	.07	240,000
			Min.	3.5	17	15	7.8	100	2.4	7.2	155	256	.01	15,000
SV 26.0 Bridge on Co. Rd. 1½ miles east of Longmont, Colo.	June-Sept.	11	Avg.	584	17	45	6.7	82	5.4	-	156	387	.05	93,000
			Max.	1833	20	140	8.6	100	11.	7.9	232	579	.06	2,400,000
			Min.	16	11	10	4.	53	2.	7.2	36	123	.02	9,300
	Oct.-April	22	Avg.	22	7	19	8.1	85	11.	-	294	450	.03	430,000
			Max.	72	17	32	10.3	101	24	8.4	343	787	.1	1,500,000
			Min.	15	0	6	6.1	74	3.8	7.7	189	255	.01	93,000

g - No data for October, November, and December.

SV 25.0 Bridge on Co. Rd. 2½ Mi. east of Longmont, Colo.	Aug-Sept.	4	Avg.	18	18	22	6.6	77	3.6	-	237	481	.03	315,000
			Max.	18	20	25	6.9	85	4.4	8.	248	523	.04	460,000
			Min.	18	15	20	6.2	66	2.3	7.9	218	446	.01	390,000
SV 23.0 Bridge on St. Rt. 185	Oct.-Nov.	7	Avg.	30.6	8	65	3.6	37	261.	-	377	828	.06	43,000,000
			Max.	32	10	70	7.2	77	304	8.4	507	855	.1	110,000,000
			Min.	30	5	60	1.9	32	240	8.1	153	800	.01	4,600,000
SV 17.4 -Boulder Creek Junction Bo 28.5 West of Boulder	June-Sept.	11	Avg.	358	15	9	8.6	104	1.2	-	24	17	.07	230
			Max.	775	20	35	9.6	110	1.6	7.3	34	36	.1	750
			Min.	100	9	1	8.	98	.5	7.1	18	10	.02	39
Bo 26. Bridge on Rt. 119 w. of Boulder	Nov.-April	21	Avg.	56.8	3	8	11.1	102	2.1	-	49	75	.05	430
			Max.	104	10	30	11.8	110	7.3	8.3	66	155	.1	24,000
			Min.	5	0	1	9.8	97	.6	7.1	32	47	.01	91
Bo 21. Beasley-Boulder Lefthand canal Intake	June-Sept.	11	Avg.	58	16	15	8.6	105	1.3	-	27	22	.06	2,400
			Max.	134	20	85	9.4	111	2.1	7.3	40	46	.1	15,000
			Min.	13	10	1	7.9	100	.8	7.	18	7	.02	230
Bo 19.0 Crossing on Hwy. 7 e. of Boulder	Nov.-April	21	Avg.	32	6	26	5.5	52	33.	-	109	112	.06	5,900,000
			Max.	100	12	45	10.3	97	64.	7.8	141	149	.1	46,000,000
			Min.	7	1	8	0	0	12.	7.1	52	69	.01	720,000
Bo 15.0 White Rock Ditch Intake	June-Sept.	11	Avg.	26	17	21	8.5	106	3.2	-	65	73	.04	43,000
			Max.	75	22	75	9.7	117	5.	8.3	93	125	.06	460,000
			Min.	0	11	4	7.9	97	1.5	7.2	32	28	.01	14,000
Bo 14.5 Crossing on Co. Rd. N.E. of Boulder	Nov.	4	Avg.	3.5	8	5	12.6	144	6.2	-	169	159	.07	43,000
			Max.	4.5	14	7	13.3	156	8.2	8.2	188	221	.1	193,000
			Min.	3	7	3	11.9	120	4.9	8.1	158	130	.03	4,300

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
							ppm.	% Sat.						
Bo 6. Coal Creek junction with Boulder Cr.	June-Sept.	11	Avg.	394	17	32	9.5	119	2.7	-	142	262	0.04	43,000
			Max.	1150	22	100	11.5	154	4.3	8.4	321	365	.1	240,000
			Min.	14	12	7	7.6	96	1.2	7.4	48	47	.01	2,300
Bo-Co 0.1 Mouth of Coal Creek	Feb. April	10	Avg.	32	8	23	10.8	111	5.	-	292	475	.04	33,000
			Max.	52	15	25	16.2	167	13.	8.5	387	650	.1	150,000
			Min.	17	2	20	7.2	69	2.2	7.5	164	210	.01	3,600
SV 3.6 First bridge above mouth of St. Vrain Creek	May	9	Avg.	231	15	227	7.1	83	6.4	-	191	493	.01	43,000
			Max.	545	19	650	9.	95	14.	8.2	270	706	.03	460,000
			Min.	60	10	25	5.	56	1.7	7.8	130	281	.01	2,300
	Mar.-April	16	Avg.	82	9	59	9.5	97	4.3	-	277	634	.03	23,000
			Max.	118	16	120	10.5	112	6.8	8.4	312	757	.05	240,000
			Min.	55	1	30	7.2	83	2.6	8.	220	480	.01	2,300
T 62.0 Adams Tunnel Outlet	June-Aug.	10	Avg.	27	14	6	7.9	101	1.6	-	17	8	.08	24
			Max.	33	20	20	8.7	109	5.	7.1	25	9	.1	200
			Min.	1	8	1	7.1	95	.7	6.9	10	2	.05	<3
	Mar.-April	7	Avg.	28	7	1	9.4	104	1.2	-	19	25	.04	23
			Max.	113	12	1	9.8	121	1.5	7.1	21	36	.07	43
			Min.	7.4	2	1	8.8	92	.7	6.9	15	14	.01	7
T 56. Bridge on Rt. 66, Estes Park, Colo.	June-Sept.	11	Avg.	600	12	4	8.5	105	1.7	-	15	5	.08	93
			Max.	1440	16	10	9.4	118	2.1	7.	18	9	.14	11,000
			Min.	65	8	1	7.2	100	1.	6.8	11	2	.06	23
	Nov.-April	11	Avg.	41	4	1	10.2	102	1.4	-	22	25	.04	23
			Max.	161	9	2	11	115	2.7	7.2	28	50	.1	240
			Min.	20	0	1	9.1	95	.4	6.9	17	14	.01	3

T 53.8 Olympus Dam Outlet below Estes Park, Colo.	June-Sept.	11	Avg.	644	13	9	8.8	109	1.5	-	17	5	.07	2,300
			Max.	1410	18	25	9.8	119	2.3	7.1	28	9	.12	24,000
			Min.	91	7	1	7.7	102	.9	6.8	14	2	.04	930
	Nov.-April	11	Avg.	54	6	3	9.5	100	2.2	-	28	29	.04	430
			Max.	299	12	6	10.9	122	4.3	7.3	34	59	.1	4,600
			Min.	18	2	1	7.6	79	.9	7.1	23	17	.01	43
T 32.3 Loveland Water Works intake	Feb.-April	13	Avg.	59	4	1	11.	104	1.6	--	29	52	.05	73
			Max.	226	12	3	12.5	127	2.8	7.4	31	120	.1	750
			Min.	18	0	1	9.2	96	.6	7.1	28	24	.02	3
T 32.3 Handy Ditch Intake	June-Sept.	11	Avg.	66	15	11	8.7	102	1.5	-	19	8	.07	1,500
			Max.	194	18	30	9.7	107	2.4	7.1	26	11	.1	4,600
			Min.	21	9	1	7.4	91	.9	6.9	16	4	.02	430
T 26.3 Bridge on Co. Rd. 2 mi. west of Loveland	Nov.-April	24	Avg.	3.6	5	1	9.7	91	2.3	-	184	561	.02	430
			Max.	16	16	6	11.3	101	12.	8.1	219	725	.04	9,300
			Min.	1	0	1	7.2	82	.8	7.6	153	283	.01	23
T 24.3 Loveland-Greeley Canal intake	June-August	8	Avg.	124	16	27	8.3	100	1.7	-	36	42	.04	930
			Max.	265	19	..	9.	105	2.4	8.	52	47	.08	2,400
			Min.	14	13	--	7.6	86	1.2	7.2	24	38	.01	430
T 23.3 Farmers Ditch Intake - Loveland	June-Aug.	12	Avg.	19	18	30	8.	100	4.	--	66	154	.04	150,000
			Max.	34	22	65	8.8	108	12.	8.	123	456	.06	2,400,000
			Min.	7	12	1	7.1	95	1.6	7.2	28	38	.01	9,100
T 22.7 Bridge on Co. Rd. 2½ m. east of Loveland	Nov.-April	24	Avg.	3	6	3	7.5	74	9.9	-	232	579	.03	445,000
			Max.	5	17	8	10.	124	21.	8.2	279	879	.06	11,000,000
			Min.	2	0	1	5.7	54	2.2	7.5	198	328	.01	43,000
T 17.9 Hillsborough Ditch intake	June-Sept.	10	Avg.	64	18	34	8.8	114	3.2	--	84	165	.03	22,500
			Max.	93	23	85	11.3	158	12.	8.4	179	428	.04	110,000
			Min.	46	13	3	7.5	89	1.2	7.3	31	38	.02	3,900

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen ppm.	Dissolved Oxygen % Sat.	5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
T 15.9 Bridge on St. Rt. 185	Nov.-April	23	Avg.	4.4	6	24	6.6	65	201.	-	307	532	.03	235,000
			Max.	5	16	130	13.3	161	904.	8.5	700	727	.04	4,300,000
			Min.	4	0	6	0	0	4.8	7.4	213	237	.01	29,000
T 9.9 Bridge on State Route 259	May	9	Avg.	19	14	21	8.7	101	2.8	--	285	889	.02	23,000
			Max.	34	18	50	10.6	125	6.1	8.3	354	1097	.04	>110,000
			Min.	9.8	12	5	6.9	75	1.7	7.8	154	417	.01	750
	Oct.-April	50	Avg.	11	6	26	10.	95	71.	--	369	647	.03	910
			Max.	15	14	85	11.9	121	515	8.3	424	1112	.07	9,300,000
			Min.	9	0	8	.2	2	1.3	7.7	277	109	.01	23
T 8.5 Big Thompson Canal intake.	June-Sept.	37	Avg.	36	19	136	8.1	100	1.7	--	166	542	.02	15,000
			Max.	72	22	950	10.1	128	3.	8.3	290	986	.04	460,000
			Min.	12	14	25	6.8	85	1.1	7.5	48	80	.01	930
T 6.4 -Little Thompson River LT 11 Bridge 1 mi. east of Larimer-Weld Co. line	May	9	Avg.	1.4	15	91	8.	93	1.6	-	323	1400	.01	15,000
			Max.	1.9	20	200	9.4	110	3.8	8.3	338	1573	.02	240,000
			Min.	1	10	25	7.5	88	.5	8.1	294	1250	.01	4,300
	Oct.-April	46	Avg.	4	5	61	10.1	92	1.7	-	365	958	.03	18,000
			Max.	6	16	130	11.	108	2.9	8.4	411	1694	.05	93,000
			Min.	1.5	0	20	8.2	76	.6	7.7	308	91	.01	2,100
LT 7. Minors Ditch Intake	June-Sept.	36	Avg.	1.4	19	295	7.1	90	2.2	-	109	333	.01	93,000
			Max.	5	22	1000	8.6	100	3.3	8.3	164	527	.03	240,000
			Min.	0	14	55	5.8	73	1.6	7.6	74	209	.01	23,000

LT 3.8 Bridge on Co. Rd. 1½ mi. s.w. of Johnstown, Colo.	May	9	Avg.	9.3	14	99	8.9	104	1.5	--	322	1400	.02	15,000
			Max.	13	18	240	9.2	113	3.4	8.4	348	1539	.03	110,000
			Min.	6.4	10	5	8.2	93	.4	8.2	282	1216	.01	930
	Oct.-April	53	Avg.	11	4	98	10.3	94	2.	-	356	932	.03	15,000
			Max.	15	14	280	11.2	112	5.	8.4	422	1895	.07	110,000
			Min.	7.6	0	30	8.	76	.6	7.9	305	109	.01	910
LT 2. Bridge on Co. Rd. 1 mi. east of Johnstown	May-Sept.	46	Avg.	39	18	497	7.2	88	4.1	--	286	1050	.02	390,000
			Max.	240	22	5400	8.	95	13.	8.3	332	1386	.03	2,400,000
			Min.	6.5	12	35	5.6	78	1.8	7.5	72	209	.01	23,000
	Oct.-April	53	Avg.	20	6	95	8.	78	37	-	365	797	.04	430,000
			Max.	24	15	310	11.7	111	138	8.7	578	1503	.07	4,600,000
			Min.	11	0	20	4.4	44	2.7	8.	291	109	.01	43,000
T 2.9 Second bridge above mouth on Co. Rd. e. of St. Rt. 60	May-Sept.	46	Avg.	369	18	164	8.7	107	2.	--	232	801	.02	43,000
			Max.	3150	22	1200	14.4	187	5.8	8.4	312	1250	.05	1,100,000
			Min.	1	10	5	6.3	73	.9	7.9	58	121	.01	2,300
	Oct.-April	48	Avg.	35	6	44	9.3	90	47.	-	351	734	.04	43,000
			Max.	63	18	120	15.7	197	445	8.2	402	1445	.07	930,000
			Min.	5.2	0	10	4.2	52	2.2	7.8	272	113	.01	930
CLP-NF 14. North Poudre Canal Intake	June-Aug.	10	Avg.	153	16	17	8.2	100	1.5	-	47	34	.12	335
			Max.	211	20	60	9.	107	2.5	7.9	60	44	.16	2,400
			Min.	50	11	4	7.8	93	.8	7.4	36	25	.04	43
CLP 49.8 Poudre Valley Canal Intake	June	6	Avg.	35	14	24	8.9	103	2.4	-	29	21	.16	190
			Max.	58	16	65	9.4	107	3.3	7.3	38	25	.18	4,600
			Min.	32	11	7	8.6	99	1.5	7.1	22	17	.15	14
CLP 41. Larimer & Weld Canal Intake	June-Aug.	9	Avg.	240	16	14	8.9	106	2.2	--	37	31	.11	430
			Max.	695	21	[illegible]	9.4	116	2.9	8.2	52	48	.18	2,400
			Min.	21	10	1	8.4	98	1.6	5.4	12	19	.04	43

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen ppm.	Dissolved Oxygen % Sat.	5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
CLP 38.8 Above Ft. Collins Power Plant on Hwy. U.S. 87	Oct.-April	25	Avg.	3.6	5	8	9.9	94	2.7	-	197	313	.03	430
			Max.	4.9	15	64	13.9	154	7.4	8.3	240	645	.15	2,400
			Min.	2.8	0	1	7.9	67	1.4	7.5	136	228	.01	91
CLP 36.5 Timnath Reservoir Intake	June-August	6	Avg.	71	18	5	6.6	82	3.7	-	171	570	.04	1,800
			Max.	182	20	10	15.2	179	6.1	8.1	244	836	.05	9,300
			Min.	2	14	1	3.5	43	2.1	7.6	74	313	.02	910
	Oct.-April	14	Avg.	16	9	12	6.9	74	19.	-	250	464	.04	335,000
			Max.	29	15	20	14.7	171	48	8.1	280	864	.1	2,400,000
			Min.	10	1	4	1.4	15	7.7	7.3	227	371	.01	43,000
Timnath Reservoir Outlet	June-August	9	Avg.	No data	19	7	7.2	93	4.4	-	233	465	.03	930
			Max.	--	22	15	9.6	128	7.8	8.2	374	627	.07	4,300
			Min.	--	15	2	1.8	23	1.7	7.5	74	209	.01	430
CLP 35.5 Spring Creek	Jan.-Feb.	9	Avg.	4.3	4	31	11.3	103	2.8	-	288	253	.02	2,300
			Max.	4.5	7	37	11.5	112	5.1	8.1	314	259	.03	9,300
			Min.	4	0	25	10.9	95	.9	8.	247	191	.01	360
CLP 35. Bridge on St. Rt. 260 below Ft. Collins, Colo.	Oct.-April	25	Avg.	4.5	7	47	7.2	68	317.	-	400	416	.03	4,300
			Max.	6	14	110	11.2	114	1410	8.3	836	648	.1	110,000,000
			Min.	2.5	0	10	.0	0	3.2	7.2	308	237	.01	230
CLP 34.3 **Fossil Creek Reservoir Inlet (north)	June-Aug.	9	Avg.	2.6	19	6	8.4	108	3.4	-	161	283	.05	3,900
			Max.	4	24	25	12.1	172	6.8	8.4	197	408	.07	24,000
			Min.	1	15	1	5.1	67	1.8	7.6	102	219	.01	2,300

	Nov.-April	14	Avg.	13	11	35	6.	67	273	-	283	766	.02	4,300
			Max.	17	14	60	13.8	167	1016	8.3	550	1500	.05	46,000,000
			Min.	3	4	6	0	0	4.6	7.2	100	396	.01	210
Fossil Creek Inlet (West) (Dry most of time)	March-April	10	Avg.	2	11	17	11.8	131	2.3	-	276	469	.02	930
			Max.	2	16	25	12.6	144	3.6	8.4	326	761	.05	2,400
			Min.	2	3	10	11.1	108	1.4	8.1	200	270	.02	43
Fossil Creek Reservoir Outlet	June-August	8	Avg.	50	20	5	4.9	66	4.6	-	202	456	.03	590
			Max.	205	23	9	7.2	99	7.1	8.3	286	560	.06	930
			Min.	2	17	1	1.5	18	2.7	7.7	109	270	.01	91
CLP 32. Bridge on St. Rt. 185	Oct.-Nov.	6	Avg.	4.5	8	2	11.1	112	3.9	-	174	948	.04	670
			Max.	4.6	13	4	12.5	135	7.6	8.	204	1003	.06	9,300
			Min.	4.5	4	1	9.8	95	2.2	8.	111	897	.01	430
CLP 21.8 Bridge on St. Rt. 259	May	9	Avg.	38	14	28	8.2	95	2.5	-	202	608	.02	9,300
			Max.	115	18	70	10.7	126	4.2	8.2	248	808	.04	240,000
			Min.	6	11	5	6.9	83	.6	7.7	156	400	.01	430
	Jan.-April	19	Avg.	11	6	17	10.8	106	2.	-	260	659	.03	2,300
			Max.	14	14	40	13.2	144	2.8	8.3	342	898	.07	9,300
			Min.	8.5	0	5	7.8	63	.8	7.7	225	113	.01	230
CLP 21.3 Ford in stream above Sugar Factory outlet at Windsor, Colo.	Oct.-March	23	Avg.	12	1	25	9.3	81	3.3	-	302	127	.04	93,000
			Max.	19	12	45	11.6	97	6.9	8.1	327	164	.06	930,000
			Min.	8.5	0	15	6.	57	1.7	7.7	275	109	.02	9,300
CLP 21. Outlet from lagoon at Sugar Factory, Windsor	Oct.-Feb.	9	Avg.	6	4	-	1.3	12	391.	-	-	-	-	930,000
			Max.	8	16	-	5.2	42	568	7.3	-	-	-	4,600,000
			Min.	0	0	-	0	0	170	6.7	-	-	-	< 36

** No flow in River below this point October-November 1949

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
							ppm.	% Sat.						
CLP 20. Bridge on St. Rt. 257, below Windsor, Colo.	May	9	Avg.	31	14	27	6.4	73	3.1	--	225	617	0.02	23,000
			Max.	94	18	55	8.2	89	4.7	8.1	307	808	.04	>110,000
			Min.	5	11	10	3.2	37	2.2	7.8	165	417	.01	2,300
	Oct.-April	46	Avg.	13	4	19	7.	62	50.	--	296	532	.03	93,000
			Max.	21	14	30	11.5	102	526	8.1	356	880	.06	9,300,000
			Min.	5	0	10	0	0	1.6	7.2	250	109	.01	23,000
CLP 14.4 Greeley Ditch #3 Intake	June-Sept.	37	Avg.	71	19	84	9.2	117	1.8	-	214	624	.02	15,000
			Max.	112	23	400	11.7	150	3.7	8.4	286	918	.04	110,000
			Min.	36	14	25	7.1	84	1.	7.5	65	107	.01	1,500
CLP 9. Bridge on Co. Rd. about 2 mi. W. of Greeley, Colo.	May	9	Avg.	2.8	17	23	11.4	138	3.1	--	284	1012	.01	930
			Max.	3.3	20	40	14.6	182	3.9	8.2	292	1063	.02	9,300
			Min.	1.8	9	15	8.8	113	2.2	7.9	280	978	.01	43
	Oct.-April	45	Avg.	25	5	25	10.2	97	20.	-	307	572	.03	9,300
			Max.	54	18	55	16.6	174	184.	8.4	360	995	.05	460,000
			Min.	1.2	0	15	1.3	21	1.1	7.4	237	55	.01	91
CLP 4.3 Bridge on road immediately below Greeley Sewage Treatment Plant	May	9	Avg.	128	16	49	9.7	116	22.	--	266	782	.02	4,300,000
			Max.	192	19	80	11.	132	33.	8.1	268	825	.03	9,300,000
			Min.	40	9	35	8.3	85	14	7.8	265	723	.01	930,000
	Oct.-April	51	Avg.	56.7	6	50	9.3	90	41	-	294	535	.04	930,000
			Max.	89	17	140	13.7	154	160	8.2	329	876	.07	43,000,000
			Min.	29	0	30	0	0	9.1	7.5	250	109	.01	230,000

CLP 4. Ogilvy Ditch Intake, below Greeley, Colo.	June-Sept.	37	Avg.	38.9	20	105	5.9	76	8.7	-	222	688	.02	2,300,000
			Max.	75	22	1000	7.7	101	20.	7.9	282	935	.05	9,300,000
			Min.	25	16	25	3.8	50	2.	7.4	68	114	.01	43,000
CLP 2.6 First bridge above mouth about 1½ mi. e. of Greeley, Colo.	May-Sept.	46	Avg.	326	19	100	7.6	96	3.5	-	244	770	.02	230,000
			Max.	2510	23	1300	11.7	148	16.	8.3	296	867	.05	2,400,000
			Min.	4	8	10	1.7	20	1.	7.5	68	120	.01	2,300
	Oct.-April	51	Avg.	64	6	31	7.8	75	30.	-	296	530	.04	750,000
			Max.	99	17	55	11.	126	192	8.2	325	879	.06	23,000,000
			Min.	39	0	20	0	0	5	7.2	252	109	.01	6,100
Cr 81.6 Crossing in Ft. Warren above Cheyenne, Wyo.	March-April	7	Avg.	2h	5	7	10.6	104	2.4	-	201	213	.05	39
			Max.	2h	10	7	11.6	116	3.4	8.3	222	243	.1	150
			Min.	2h	0	6	10.1	87	1.1	8.	151	198	.02	7
Cr 77.0 Crossing at U.S. Hwy. 85-87	Nov.-March	11	Avg.	2.6	6	46	10.3	104	3.5	-	241	231	.06	9,300
			Max.	3	12	110	14.7	163	5.3	8.7	273	243	.1	43,000
			Min.	1.8	2	6	5.5	62	1.7	7.9	205	213	.03	1,500
Cr 76.3 Storm Sewer Outlet, Cheyenne, Wyo.	August	3	Avg.	No data	21	22	4.9	68	20.	-	97	92	.08	15,000
			Max.	---	24	30	5.4	73	30.	7.7	108	105	.1	46,000
			Min.	---	18	10	4.3	61	9.4	7.6	84	86	.06	3,900
Cr 76.0 Below Refinery and Cheyenne Sewer Outfall above sewage Lagoons.	August-Nov.	7	Avg.	6	14	27	.4	4	55.	-	253	194	.14	4,300,000
			Max.	6	21	30	1.8	20	78.	8.7	291	235	.25	11,000,000
			Min.	6	8	25	0	0	36.	8.2	210	152	.07	430,000
Cr 72.5 Crossing on Rd. below sewage Lagoons at Hereford Ranch	June-August	9	Avg.	40	18	24	4.6	60	10.	-	251	197	.13	24,000
			Max.	117	20	35	6.8	84	20.	7.9	329	238	.2	460,000
			Min.	0.5	15	6	2.6	36	6.1	7.3	200	152	.08	4,300

h - No data for April.

SUMMARY OF SEASONAL RESULTS (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)	(12)	(13)	(14)
Sampling Point Mileage from Mouth	Sampling period	No. of samples	Result	Stream Flow c.f.s.	Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD ppm.	pH	Alkalinity, ppm.	Hardness, ppm.	Copper, ppm.	Coliforms* M.P.N. per 100 ml.
							ppm.	% Sat.						
Cr 72.5 (Cont.)	Nov.-April	11	Avg.	26	7	48	7.6	78	19.	--	267	228	.07	24,000
			Max.	75	11	85	12.2	128	41.	8.7	324	249	.1	4,600,000
			Min.	5.6	4	30	3.	28	8.4	7.7	226	203	.04	3,600
Lod 112.8 Oliver Reservoir inlet at Bushnell, Nebr.	May-Sept.	13	Avg.	13.6	16	54	8.1	94	4.	--	208	176	.05	1,500
			Max.	42	20	400	8.7	103	11.	8.3	227	380	.08	24,000
			Min.	9	12	1	6.8	73	1.8	7.7	173	162	.01	36
	Oct.	2	Avg.	--	-	-	-	-	-	-	-	-	-	-
			Max.	10	12	-	9.5	102	3.5	8.	215	143	.04	4,300
			Min.	10	10	-	8.5	94	2.7	8.	-	-	.01	1,500
Lod 111.2 Oliver Reservoir Outlet	May-July	10	Avg.	17.9	18	7	5.7	67	3.8	--	174	165	.06	930
			Max.	37	22	15	9.2	104	5.1	8.4	198	289	.08	24,000
			Min.	0.4	10	1	2.2	30	1.5	7.9	154	114	.04	93
Lod 101.0 Bennett Reservoir Inlet below Kimball, Nebr.	May-Sept.	11	Avg.	5.9	17	8	7.3	90	3.6	-	209	170	.04	43,000
			Max.	11	20	15	9.2	110	>7.5	8.7	249	180	.07	110,000
			Min.	0.1	10	2	2.	24	1.9	8.	176	152	.01	39
	Oct.	2	Avg.	--	-	--	-	--	-	-	-	-	-	-
			Max.	4.7	13	--	7.5	83	6.5	8.	234	162	.03	93,000
			Min.	4.5	12	-	7.4	82	4.8	8.	-	-	.01	43,000
Lod 100.3 Bennett Reservoir Outlet	July	6	Avg.	No data	22	6	8.4	110	6.3	-	132	101	.03	106
			Max.	--	23	10	9.2	120	9.6	9.4	139	133	.04	460
			Min.	--	20	4	6.3	84	3.4	9.2	124	76	.01	43

Lod 55.7 Below Sewage Disposal Plant, Sidney, Nebr.	May-Sept.	13	Avg.	141	20	5	9.7	122	7.6	--	227	231	.05	93,000
			Max.	1800	28	1500	12.5	157	11.	8.4	296	532	.1	930,000
			Min.	1.5	12	2	4.9	57	2.2	7.9	181	133	.01	15,000
	Oct.-Dec.	14	Avg.	2.4	8	12	6.2	62	9.6	--	252	179	.07	390,000
			Max.	4.1	16	45	11.3	131	17.	7.9	278	234	.1	2,400,000
			Min.	1.1	3	1	4.8	48	6.2	7.7	152	104	.04	43,000
Lod 26.8 Bridge on Co. Rd. s. of Lodgepole, Nebr.	May	4	Avg.	86	17	110	7.3	86	5.6	--	280	237	.09	4,250
			Max.	275	21	130	8.4	96	7.4	8.1	306	350	.1	11,000
			Min.	12	15	95	6.	69	4.8	7.8	226	142	.06	230
Lod 12.0 Crossing south of Chappell, Nebr.	May-Sept.	13	Avg.	30.2	21	46	7.2	91	5.3	--	271	212	.06	4,300
			Max.	225	26	110	9.6	108	7.2	8.4	338	380	.1	24,000
			Min.	8	15	15	5.9	76	2.4	8.	212	133	.01	430
	Oct.-Dec.	8	Avg.	14	6	16	12.	106	2.9	--	238	211	.02	375
			Max.	22	17	20	13.4	117	5.8	8.4	294	234	.03	2,300
			Min.	10	0	15	9.	93	1.6	7.7	198	143	.01	91
Lod 0.5 Crossing at Ovid, Colo. on Hwy. 138	May-Sept.	13	Avg.	24	22	42	7.9	101	4.2	-	213	382	.03	2,400
			Max.	114	28	60	9.	122	6.9	8.4	259	532	.06	46,000
			Min.	6	15	15	6.8	86	1.5	8.2	164	181	.01	430
	Oct.	7	Avg.	207	14	27	9.1	99	3.8	-	198	406	.02	6,950
			Max.	275	18	110	9.6	102	5.3	8.4	204	494	.04	24,000
			Min.	172	10	15	8.7	96	3.2	7.3	190	342	.01	4,300

* Coliforms expressed as median value and not average.

Hydrometric Data

Low-Flow Frequencies

A study was made of published stream flow data covering established gaging stations on the South Platte River and its principal tributaries in order to arrive at a low mean monthly flow frequency value. These frequencies were determined for both summer (May-September) and winter (October-April) flow conditions. Only those gaging stations where records extended for periods in excess of 15 years were included in this analysis. Tables SP-10, ClP-3, SV-4, T-4, and Cl-4 show the results of these studies. Discussions of the individual results are included in the sub-basin sections of this report.

The results obtained are of considerable interest. With few exceptions, the lowest flows may be expected in the winter period on all perennial streams in the basin. The effects of diversion during the summer months are quite apparent on most streams as there are little or no relationships between the gaging station locations and the magnitude of the stream flows. This effect is especially noticeable on Clear Creek between Golden and the mouth; on Thompson River between Drake and the mouth; on the Cache la Poudre from above Ft. Collins to the mouth; and on the South Platte River between Sublette and the mouth. Critical flow conditions occur where diversions deplete the flow to zero beyond the diversion point. This occurs at many points along the streams in the basin. However, such conditions are rarely recorded at gaging stations unless they are located immediately below the diversion points.

Effects of Project Operations

The following discussion was prepared from material furnished by the South Platte River District Office of the Bureau of Reclamation for inclusion in this report. This discussion is based upon the best current information available for estimating the critical flows which will result after completion of the Colorado-Big Thompson, the Blue-South Platte, and the Narrows Reservoir Projects. These estimated effects and critical flows can and may be considerably altered by changes and revisions of current plans or of the assumptions upon which they are based. The final allocation of Colorado-Big Thompson Project water supply among the St. Vrain, Big Thompson, and Poudre Rivers has not been made, and any change in allocation from that anticipated would affect the quantity of water delivered to the various streams. Potential projects such as the Blue-South Platte are subject to considerable revision before construction. The addition of about 700,000 acre-feet annually to the present water resources of the basin by these projects may, and probably will, have effects not visualized. This amount of imported water will increase present resources by about 25%, not counting reuse resulting from return flow. Increased return flows to the streams should have a beneficial effect upon low-flow conditions. The effects will not be uniform over the basin. However, the extent to which this may occur cannot now be determined. In any event, it is unlikely that low-flow improvements will be sufficient at points in the basin below diversions to materially affect the need for adequate sewage and industrial waste treatment, even if the maximum quantities of water anticipated are delivered.

Under the present plans the Colorado-Big Thompson Project will deliver project water to the Cache la Poudre River, Big Thompson River, St. Vrain Creek, and possibly to Boulder Creek. Water will be delivered to 4 delivery points under a contract with the Northern Colorado Water Conservancy District:

1. The Cache la Poudre River - about 8 miles upstream from Ft. Collins above the Poudre Valley Canal intake.

2. Big Thompson River - about 8 miles above Loveland immediately above the Handy Ditch intake.

3. Little Thompson River - near Lyons above all irrigation diversions.

4. St. Vrain Creek - near western city limits of Lyons.

The Blue-South Platte Project, under present plans, would deliver additional water to Bear, Clear, South Boulder, and Boulder Creeks, and to the South Platte River. Further discussions on the anticipated or estimated effects of the operation of these projects will be found under the various subbasin sections.

Table 35 **Average Water Temperatures**

Month	Headwaters Streams[1]		Middle So. Platte[2]		Lower So. Platte[3]	
	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.
January	0	32	0	32	**	
February	3	37	2	36	**	
March	3	37	7	45	**	
April	7	45	12	54	**	
May	12	54	16	61	16	61
June	11	52	19	66	**	
July	13	55	22	72	24	75
August	16	61	22	72	**	
September	13	55	16	61	14	57
October	**		12	54	13	55
November	3	37	4	39	6	43
December	0	32	1	34	2	36

1 - Average of Stations Cl-38.5, T-62 and T-56
2 - Average at Station SP-234.5
3 - Average at Stations SP-98.1, SP-90 and SP-3.5

** No samples taken during month from streams in this area

DISCUSSION

Pollution Damages to Water Resources

Discussions of the damages to water resources because of pollution will be found throughout the various sections of the subbasin reports. However, a brief recapitulation of this subject is presented below which will serve to give a generalized picture of the conditions in the basin as a whole.

Public Health and Pollution of Irrigation Waters

There are public health problems associated with the use of waters containing sewage for irrigation purposes. There are no reliable criteria at the present time which are applicable as yardsticks with which to measure the degree of these hazards. The dangers are in general recognized but the extent to which they exist under actual conditions is not too well established. The principal lack of information is in the field of epidemiology. Studies are being planned in this field. (See Supplement to Appendix "G" for a partial review of the literature concerning the public health aspects of irrigation with sewage-polluted waters).

There are no generally accepted criteria by which the relative safety of irrigation waters may be determined. Sewage treatment requirements and acceptable standards of bacterial purity for waters used for irrigation purposes are now largely a matter of judgment and experience. Whether or not current practices in this regard are satisfactory is a moot question which can only be answered after adequate bacteriological and epidemiological studies have been made. The rapid growth of the western states during the past 20 years or more has resulted in certain complications with regard to the use of surface waters for irrigation purposes. As population has increased, the pollution load upon the streams has also increased. Since in many areas waters which do not contain sewage are not available for irrigation use, it is becoming more important to establish criteria which may be used for the purpose of measuring the relative danger of these waters for the irrigation of certain types of crops, particularly vegetables and small fruit - some of which may be consumed in the raw state.

Bacteriological studies of sewage-laden waters used for the irrigation of small fruits and vegetables have been under way. The object of these studies is to obtain data which will aid in the establishment of reliable criteria for the eventual setting of standards of sanitation required for irrigation waters. Appendix "G" outlines the results of studies carried out concurrently with the water pollution investigation of the South Platte River. These studies confirm that vegetables irrigated with polluted waters carry greater concentrations of bacteria of the coliform group than do vegetables irrigated with nonpolluted water.

In the consideration of the public health hazards resulting from the use of irrigation waters polluted by sewage, the types of crops are important. Low-growing fruits and vegetables, especially those which are normally consumed in the raw state, probably have the greatest significance. In addition, possible hazards to livestock, particularly dairy cattle, pastured on lands irrigated with sewage-laden waters, must be given consideration. The transmission of enteric parasites, such as the tapeworms, by this means, is well recognized.

In the process of irrigation, the sewage-laden waters are spread over relatively large land areas and the opportunities for transmission of infection are greatly increased thereby.

The coliform content of streams has long been used as a measure of pollution. These data are subject to interpretation in the light of known pollution sources. High coliform numbers below a sewer outfall are more significant than a similar content in a sparsely inhabited area. Enterococci bacteria are also a sensitive indicator of the presence of sewage pollution. These bacteria have been isolated from sewage, irrigation water, and certain of the irrigated vegetables themselves (See Appendix "G"). The public health implications of these findings cannot be ignored. The solution to the problem is waste treatment or elimination.

The treatment of sewage will remove bacteria in proportion to the type, degree, and efficiency of the process used. Sewage treatment, however, will not completely remove disease-causing organisms. Imhoff and Fair* estimate the bacterial efficiency of various sewage treatment processes as follows:

Type of Treatment	Bacterial Removal - Per Cent
Primary	25-75
With chlorination	90-95
Chemical precipitation	40-80
Secondary	
Trickling filter - complete	90-95
Activated sludge	90-98
Intermittent sand filtration	95-98
Any of above with chlorination	.98-99

Chlorination for disinfection of sewage treatment plant effluents is provided in some plants in the South Platte Basin. However, most plants make no provision for this safeguard. Adequate chlorination should be a requirement of all domestic sewage treatment plants now in operation or constructed in the future, in order to provide the maximum possible safeguard for irrigation usage of the stream waters in the basin. Adequate chlorination means the practical application of chlorine to domestic sewage treatment plant effluents as necessary for the protection of downstream water quality and reasonable uses and includes facilities for proper dosage, contact time, and control of the chlorination process.

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* Reproduced by permission from SEWAGE TREATMENT by K. Imhoff and G. Fair, published by John Wiley & Sons, Inc., 1940.

In common with other arid and semiarid regions, water has an unusually high value in this basin. Increased water needs and the limited water supply have led to vast undertakings to augment the water resources of the basin. These undertakings have been directed towards the importation of water into the South Platte River Basin from the western slope of the Continental Divide. One of the keystones of the regional economy is agriculture. In this region a well-diversified agriculture is based upon the availability of water for irrigation purposes. The lack of sufficient water suitable for agricultural purposes could lead to great hardship and even to the abandonment of highly productive agricultural land. Therefore, the use of water in the basin should be governed to a considerable extent by the amount and the quality of water required for irrigation purposes.

Neglecting entirely the health and other aspects of the water problem and basing the discussion solely upon consideration of agricultural economy, it would appear that, after domestic water needs have been satisfied, the estalished economy of the region would require that the need for water for agricultural purposes must be met. That this water should be of a quality suitable for irrigation and other agricultural needs is obvious. The responsibility for maintenance of suitable water quality rests with the communities and the industries in the basin. The elimination of water pollution or the furnishing of additional waste treatment facilities over and above those now provided would afford economic insurance through the continued maintenance of suitable irrigation water quality. Neglect to take this step could affect the agricultural economy either because of the loss in production or because of reduction in market value of inferior crops. A case in point would be a serious loss of crop value which could result from a public boycott of irrigated crops because of a recognized health hazard associated with the use of contaminated water for irrigation purposes. This situation has a special significance in the area immediately north of Denver in that a large acreage in this region is devoted entirely to cultivation of truck crops. A considerable acreage adjacent to the mouth of Clear Creek and extending northward to the vicinity of Ft. Lupton uses available water from the South Platte River and from Clear Creek for irrigation purposes. There is no surface water available in this region which does not contain a relatively large proportion of the waste discharges from the various communities and industries located therein. Since the crops produced in this area are in excess of local consumption, the problem assumes more than local importance because the excess production is shipped to other population centers, some of which are in other states. High monetary returns per acre from production of truck crops make the expansion of this agricultural pursuit attractive where land values are high and where ready markets for the produce are available. Further, the increased cost of irrigation water because of higher construction and maintenance costs is an incentive for the farmer to increase his returns per acre. While, as stated previously, there are no reliable criteria at the present time which are applicable as yardsticks with which to measure the degree of these hazards, an outbreak of disease associated in any manner with produce irrigated with water containing appreciable amounts of sewage would seriously affect this agricultural industry and would result in much unfavorable publicity and serious damage to the industry. It is, therefore, incumbent upon the communities and industries to conserve water resources through the provision of adequate pollution abatement facilities.

Colorado State Health Department Requirements - Colorado restrictions on the use of water contaminated with sewage for irrigation purposes are covered under Rule 20 of "Regulations Relating to Sanitary Engineering, Public Water Supplies, Water Purification Plants, Sewer Systems, and Sewage Treatment Plants." This regulation* states in part as follows:

> "Rule 20. Irrigation with sewage or sewage-laden water. No domestic sewage nor water containing domestic sewage in amount and condition such that bacteria of the coli-aerogenes group (Coliforms) are present in quantities of ten or more per cubic centimeter, shall be used to irrigate or be permitted to overflow any fruits or vegetables for human consumption, the edible portions of which grow in the ground or above it within one foot of the surface, except with the written permission of the State Board of Health obtained as hereinafter provided."

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* Colorado State Division of Public Health Laws, Rules and Regulations (Revised 1942), Colorado State Board of Health, Denver, Colorado, p. 164.

> "Upon receipt of a request, in writing, for permission to use sewage or sewage-laden water contrary to the above stipulations, claiming that the conditions of the particular case are such as to prevent any reasonable possibility of impairing the public health and stating full details upon which this claim is based, the State Board of Health will make an investigation and determine whether or not such use should be permitted, following which, its approval will be given or denied."

Under the above regulation, the limiting value for the coliform content of sewage or sewage-laden water used for irrigation is 1,000 per 100 milliliters. Practically speaking, this rule is unenforceable and further it is doubtful that such a rule is legal under recently enacted health laws.

Public Water Supplies

Damages to public water supplies from pollution are not of great importance in the South Platte Basin. This is because there are no supplies taken directly from the streams in the plains area. Surface water sources used for public water supplies in this basin are obtained from headwater streams or from canals fed by headwater streams. Catchment areas of limited extent are protected and patrolled. Laboratory results indicate that the raw waters in the regions from which public water supplies are derived generally have bacterial quality which permits their use with appropriate water treatment. Communities located in the plains area obtain their water supplies from ground water sources.

Industrial Water Supplies

Industrial water supplies in this basin are, for the most part, obtained from public water supplies, except where large amounts of cooling waters are required, in which case stream or irrigation waters are often used for this purpose. A few industrial plants located outside of municipalities have individual well water supplies for their operation. The use of waters containing beet wastes would not be satisfactory for many industrial purposes because of the high dissolved organic solids in these wastes and because of the tendency of these wastes to foam when agitated. Further, such waters are not suitable for any use which would require a clear, odor-free water.

Agriculture

Damages to water supplies used for agricultural purposes by discharge of sewage and industrial wastes into the streams are largely concerned with the use of these waters for irrigation and for livestock. These damages would result from the limitation placed upon the use of the water for certain types of crops, or from the hazards to human or animal consumers of these waters, or of the crops irrigated by them. Restricted use of water containing sewage for irrigation purposes would prevent the growing of high value truck crops in certain cases, resulting in considerable loss of income to those farmers engaged in this type of crop production. The use of sewage-laden waters for livestock purposes may be hazardous in that certain intestinal parasites may be transmitted to the animals, and dairy cattle may have their udders contaminated from such waters. Further, forage crops and pasture lands irrigated with such waters may be the source of livestock infection by intestinal and other parasites which are resistant to natural forces. This subject is discussed in more detail in Appendix "G."

Recreational Facilities

The headwater streams in the basin are extensively used for recreational purposes, including fishing. Irrigation and other water uses in the plains area render the streams unfit for extensive recreational usage. The use of water for irrigation, alone, prevents its use for recreation, even though adequate waste treatment practices are followed in every community. This is because irrigation usage has profound effects upon the stream flow. These effects are not uniform over the basin. The diversion of the total stream flow in places causes the stream to become dry below the diversion point. Although this condition does not persist for any great distance because of the effects of return flow, these short stretches are sufficient to render the stream unfit for continued maintenance of abundant fish life. Further, in most cases, as soon as the replenished stream flow has built up to a sufficient quantity, rediversion of the flow is a foregone conclusion. Therefore, streams in the plains areas can never be extensively utilized for recreation.

Benefits Resulting from Pollution Prevention and Abatement

Beet Sugar Wastes

The major organic pollution concentration in the South Platte Basin is found in the industrial wastes contributed by the seasonal operation of beet sugar factories. The total estimated population equivalent of these wastes for the entire basin reaches a figure in excess of 4,000,000. The removal of this tremendous load would result in stream improvement in the entire South Platte River Basin during the beet processing season. Considerable investigation was conducted on the problem of beet sugar factory wastes during the course of this water pollution survey of the South Platte River. It would appear to be quite feasible to remove a large part of this waste load by elimination of certain waste components and by re-use of certain process waters. Theoretically, all of the wastes from the beet sugar industry could be eliminated from the streams. This elimination could be accomplished in a number of steps: (1) the installation of pulp dryers at all plants to remove silo drainage wastes which form a large proportion of the waste load; (2) the separation and lagooning of the lime cake wastes which are a potent source of pollution; (3) the lagooning, or the conditioning for use as a by-product, of all the Steffens wastes from those plants which employ this process; (4) the conditioning and re-use of process waters resulting from the transportation of spent pulp and the waters from the pulp dryer presses; and (5) the settling and re-use of flume waters. The accomplishment of the first four items above would result in the reduction of pollution load to the streams by about 80%.

Benefits attributable to this removal would be both tangible and intangible. Tangible benefits to the industry, which would result from the above, would be a better utilization of the spent pulp as a feed which could be marketed over the entire year rather than over a short period during plant operation. The re-use of process waters would result in conservation of water, possibly reducing somewhat the cost of this item. The same may be said about the re-use of flume waters. However, the additional costs of treatment and pumping may offset any savings accruing from these practices. Lime cake could be utilized to fill in low ground areas, and thus reclaim bottom lands not now serving any useful purpose. Further, the removal of the wastes from the streams would bring about better conditions in storage reservoirs which now receive waters containing these wastes. These reservoirs are the source of nuisance conditions in the early spring because of advanced decomposition of organic material in the waters. Benefits would result from the general clearing up of nuisance conditions which now exist in the streams below points of waste discharge and which are a source of annoyance to those living in the vicinity of the stream. Further, the use of the water containing these wastes may be restricted because of unsatisfactory stream conditions.

Intangible benefits from the removal of these wastes from the streams would result in an increase in the general morale of the public who have become somewhat accustomed to looking forward with distaste to the seasonal operation of these plants. Further, it is believed that some of this benefit reflects itself in the betterment of public relations between the manufacturers and the residents of the affected areas.

Municipal Sewage

One problem which confronts the entire basin is the high bacterial content of sewage-laden waters found below communities which discharge their treated or untreated wastes into the watercourses. This condition presents a potential hazard to the public health where the waste-laden waters are diverted for irrigation purposes shortly below waste discharges. This potential hazard could be lessened by the general adoption of the practice of chlorinating domestic sewage treatment plant effluents throughout the South Platte River Basin.

Pollution Prevention Measures in Effect

Pollution prevention measures in effect in the South Platte River Basin are largely those which deal with the treatment of sewage from communities in the basin. There are few industrial establishments which provide treatment for their wastes before discharging them into the nearest watercourse. In those cases where industrial wastes are given treatment, this treatment is, for the most part, designed to remove gross solids only, or the wastes from the industry are discharged into the municipal sewer system and treated along with municipal sewage. There are a number of places in the basin where it would be advantageous for industry and the adjacent community to join their resources to the extent of constructing suitable joint waste disposal facilities. An encouraging step in this direction has been taken in the case of Golden where a large industry situated adjacent to the community is undertaking the construction of a sewage treatment plant which will serve to treat the wastes from the industry and from the community. This is noteworthy in that no other case is known where industry has assumed the primary responsibility for the construction and maintenance of a joint municipal-industrial waste treatment plant. In this case the community will reimburse the industry for their share of the plant maintenance and operation, based upon their pro rata share of the plant loading.

Sanitation Districts

Another noticeable trend in the South Platte Basin has been the recent creation of sanitation districts which have and are constructing sewer systems and sewage disposal plants to serve areas which could not otherwise afford such services. Two such districts have recently constructed sewage treatment plants in suburban areas adjacent to the City of Denver. In this regard the State of Wyoming has quite recently passed legislation covering the formation of sanitation districts outside of incorporated areas.

Colorado Game and Fish Department

The Colorado Game and Fish Department has been active in pollution abatement work, particularly as it concerns the wastes created by the mining industry. Their efforts have resulted in the partial abatement of pollution from this source in those areas of the South Platte Basin where such wastes are a problem. Additional work is needed.

Pollution Abatement Project Status

Table 36 lists the status of pollution abatement progress in the basin as of January 1, 1950.

Table 36 Pollution Abatement Project Status - January 1, 1950

Status	Number	
	Municipal	Industry
No Action Known as of January 1, 1950	43	37
Abatement Ordered	0	6
Engineer Employed	2	0
Final Plans Approved	0	0
Construction Awaiting Financing	0	0
Contract Awarded	3[a]	1[b]
Status Undetermined	0	0

[a] - Under construction.
[b] - Sugar factory reconversion; under construction.

Pollution Abatement Needs

Stream Flow for Waste Dilution

From a practical standpoint, the stream flow situations in the basin are governed by two prime factors: (1) irrigation demands in the summer months; (2) the available runoff and storage demands in the winter months. The normal flow patterns of the perennial streams in this basin are such that maximum runoff occurs in the early summer months of June and July and sometimes August. The exact time for any given year will depend upon the temperatures prevailing in the late spring which govern the snow melt in the mountains. The minimum stream flows occur in the winter months from November to March or April. This is because the water available for runoff is locked in the snow and ice formations during the long winter months. Irrigation, and most storage demands as well, are satisfied from the spring and summer flood flows, although some storage demands are satisfied only during the winter months when adequate flows are available for this purpose.

A number of tributaries in the basin, generally those which arise in the plains area and enter the South Platte River from the south, and also a few which arise along the Colorado-Nebraska line, are streams of intermittent flow. These streams are not fed from the slow-melting mountain snows. They obtain their water sources in the melt of snow on the plains in the spring and from local rainfall in the summer. These streams often contribute considerable runoff to the South Platte River, especially below Kersey, as the result of flash floods due to quick snow melt in the early spring or to intensive rainfall during summer storms.

Water usage for irrigation, as explained elsewhere in the report, is governed by the public ownership of all stream waters and the appropriation of these waters by law and by court decrees on a priority basis for consumptive use. Adjudicated claims for water are far in excess of the maximum available runoff of the streams. This situation limits the flows in the stream proper to that water which diversions are unable to handle, or to return flows which exist as streamflow only until they can be diverted for re-use.

Increased stream flows are contemplated as the result of projects conceived by the Bureau of Reclamation. These projects are dependent upon the importation of water from other stream basins to the South Platte River Basin. One project, the Colorado-Big Thompson (Exhibit I), is in the process of construction; another, the Blue-South Platte River Project (Exhibit II), is in the planning stage. Neither is in operation as planned, although some water is entering the Thompson River through completed portions of the Colorado-Big Thompson Project.

The estimation of stream flows for sanitation purposes has been suggested as a guide for reservoir releases so that sufficient dilution water may be made available at critical times to assist in the alleviation of unsatisfactory stream conditions existing at various points in the basin. Projects are designed for multiple-purpose operation combining irrigation, flood control, and power development; the latter two are subservient to the former. The main operating reservoir for the Colorado-Big Thompson Project will be Horsetooth which will supply project water to the various distribution points. The proposed Blue-South Platte Project will utilize the Two-Fork and Cherry Creek Reservoirs and probably storage space in Chatfield Reservoir. In both projects, water releases will be governed by the primary purposes for which the projects are built, which will, of necessity, dictate the water release schedules to be put in force. The major effects of the reservoir storage will be the leveling off of flood flows so that the water may be stored and released for use as required to satisfy irrigation and other demands. In the consideration of stream flow for waste dilution, it is taken into account that all communities and industries will provide for treatment of their wastes in order to eliminate critical stream pollution situations. This action in all probability will result from action by the State, or because of damage suits, or for the protection of public health, or as the result of pressure to alleviate water pollution arising from public desire to maintain cleaner streams. In general, suitable treatment or waste elimination processes are available for the correction of existing conditions. Inasmuch as there is a definite relationship existing between the allowable volume and strength of any given waste discharge and the amount of stream flow available in the receiving watercourse for dilution, it is sometimes possible to bring about a reduction in the degree of treatment necessary by increasing the water available for dilution purposes. Any savings which may accrue in capital costs or in operation costs resulting from a lessening of the degree of waste treatment required at any given point through increase in stream flow at that point can be credited to benefits from project operation.

The only project which will shortly affect the South Platte River Basin is that of the Colorado-Big Thompson. Project water will be supplied to the Poudre and Thompson Rivers and to the St. Vrain Creek system. Under currently anticipated operational procedures, the full effects of these increased flows will be available only above points of diversion. Since the appropriation of water is much greater than the supply, any increased flows will be utilized to fulfill obligations to the water users. This is the basis upon which the project was conceived and justified from the standpoint of irrigation. The effects would be an increase in the amounts of diversions and, unless ditches with a large allotment of project water existed below the point of need, stream flows would not reach the desired level.

The conclusion is that inasmuch as the water resources of the Basin are already highly developed principally for irrigation purposes, the plans for their further development do not hold promise for pollution abatement through stream regulation.

Municipal Sewage

There is a definite relationship existing between stream flow and the amount of wastes of a given character which can be discharged to the stream. Generally speaking, low-flow conditions govern the amounts of wastes which the stream may absorb without creation of unsatisfactory conditions. When stream flows fall below the amounts necessary to maintain satisfactory conditions with any given waste discharge, it becomes necessary to alter the characteristics of the waste by suitable treatment in order to preserve the integrity of the stream. The degree and efficiency of treatment required in any given case is dependent upon the size of the waste loading in relation to the minimum stream flow. Where flows are too low to permit use of partial treatment, more complete treatment methods are required. The availability of sufficient dilution water, alone, will not obviate the necessity for sewage or waste treatment which would remove bacteria and objectionable floating materials and prevent the formation of sludge banks in the stream. The elimination of these undesirable characteristics of the wastes would require primary treatment for ordinary sewage before being discharged to the receiving streams of the South Platte Basin. The requirements for further treatment will depend upon the use to be made of the water at downstream points, and upon the conditions created in the stream by the primary effluent. One criterion which will govern the degree of sewage treatment necessary is the amount of dissolved oxygen maintained in the stream below the point of waste discharge. Analysis of the laboratory data shows that, for much of the basin, maintenance of adequate dissolved oxygen levels in the streams is not a serious problem either in the summer under high stream temperatures or in the winter under low stream temperatures. This statement is based upon consideration of average results. Critical conditions in the stream are indicated by the minimum dissolved oxygen results. These occurred more often in the winter months when stream flows were at their lowest ebb. Maximum dissolved oxygen depletions were very often the result of seasonal industrial operations during the late fall. Recovery of the stream was usually prompt after cessation of operations. In some instances, however, sustained low oxygen levels resulted from the discharge of wastes from communities and industries. In these cases, the only remedy is the installation of adequate waste treatment which would maintain satisfactory dissolved oxygen levels in the stream. A minimum value of 5.0 ppm is considered necessary for the maintenance of a balanced aquatic life in the stream.

From the standpoint of irrigation usage, consideration must be given to public health hazards inherent in the use of waters containing sewage. Data obtained during the course of the survey revealed sustained high coliform concentrations throughout the areas primarily concerned with irrigation water usage.

Effective chlorination of waste treatment plant effluents is the best method of dealing with bacterial pollution.

Industrial Wastes

Beet Sugar Industry - A requirement deemed necessary for pollution abatement in the South Platte Basin is the treatment or removal of industrial wastes which place extraordinary pollution loads upon the streams. Foremost among these wastes are those contributed by the beet sugar industry. Discussions concerning these wastes may be found elsewhere in this report.

Packing Industry - The next largest industrial waste loading in the basin is contributed by the packing industry. Fortunately, the bulk of these wastes are produced in the City of Denver and are handled by the Denver sewage treatment plant. In those cases where packing house wastes do not reach municipal sewage treatment plants, such wastes should be given treatment by the industries before being discharged into the streams. The degree of treatment required will depend to a large extent upon the location of the industry, its size, and the receiving stream into which the wastes are discharged.

Canning Industry - Canneries discharging wastes directly into the streams should provide for treatment to the point where the stream is able to assimilate them without creating nuisance. Where possible, the wastes can be treated along with municipal sewage. However, this is not always a good solution in that the cannery wastes are seasonal and the extra capacity required in the municipal treatment plant may not be economically feasible.

Other Industries - Other industries discharging wastes directly into the streams should provide for adequate treatment of these wastes before discharge. There are a number of dairies and other milk processing plants located throughout the basin which should provide some type of treatment for their wastes. Where it is possible, connection to the municipal sewage treatment plant would probably be the best and easiest solution to their problem. Improved housekeeping methods and simple waste collection devices can be utilized to good advantage in reducing the present waste loadings attributable to these establishments. The degree of treatment required at any particular plant will depend to a large extent upon its location and size and upon the nature of the receiving streams.

The mining industry in the basin contributes wastes largely through the operation of ore processing mills which discharge tailings to the streams. Current practice requires the installation of tailings ponds which are essentially lagoons used for the settling out of the suspended materials. Overflow from the ponds is discharged to the streams, or the water is permitted to seep into the ground or evaporate. Coal mines and hard rock mining operations are not productive of wastes which tend to create water pollution problems in this basin.

Oil refineries located within the basin provide for waste treatment directed solely toward the recovery of oil and the prevention of its access to the streams. Additional pollution correction measures are needed.

There are a number of small industrial establishments scattered throughout the South Platte River Basin which discharge wastes without treatment into the basin watercourses. Wherever possible, these establishments should be connected to municipal sewage treatment plants. Otherwise, adequate treatment should be provided for their wastes before discharge into any watercourses.

Tables 37, 38, and 39 summarize the adequacy, requirements, and recommendations of waste treatment facilities in the South Platte River Basin as determined from available data.

Table 37 Adequacy of Waste Treatment Facilities

Existing Treatment Facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	36	21	5	10	18	8	10
Industrial	23	20	3	0	17	6	0

Industrial wastes present a very serious and complex water pollution problem throughout much of the South Platte Basin. Correction of industrial waste pollution is feasible and should be provided as rapidly as possible in order to protect the region's limited water resources and allow their maximum utilization.

Table 38 - Municipal Sewage Treatment Needs and Recommendations

Community	Drainage Basin	Needs	Status*
Colorado			
Littleton	S.Platte R.	Provide additional primary clarif; secondary clarif.; chlorination	8
Denver (Main)	S.Platte R.	(a) Increased capacity	2
		(b) Higher degree of treatment	8
		(c) Effective chlorination	2
Brighton	S.Platte R.	Secondary settling and chlorination	8
Ft. Lupton	S.Platte R.	Secondary treatment and chlorination	8
Platteville	S.Platte R.	Secondary treatment and chlorination	8
LaSalle	S.Platte R.	Secondary treatment and chlorination	8
Evans	S.Platte R.	Abate pollution from individual septic tanks	8
Ft.Morgan	S.Platte R.	Secondary treatment and chlorination	8
Brush	S.Platte R.	Secondary treatment and chlorination	8
Merino	S.Platte R.	Secondary treatment and chlorination	8
Sterling	S.Platte R.	Secondary treatment and chlorination	8
Ovid	S.Platte R.	Secondary treatment and chlorination	8
Julesburg	S.Platte R.	Secondary treatment and chlorination	8
Castle Rock	Plum Creek	Replace existing plant	8
Fed.Correctional Institution	Bear Creek	Secondary settling and chlorination	8
Fort Logan	Bear Creek	None	1
Loretto Heights College	Bear Creek	Secondary treatment and chlorination	9
Buckley Field	Sand Creek	Better operation and chlorination	8
Fitzsimons Hosp.	Sand Creek	None	1
Aurora	Sand Creek	Additional capacity, secondary treatment and chlorination	8
Denver(East side)	Sand Creek	Secondary treatment and chlorination	8
Deer Trail	Bijou Creek	Treatment plant providing for secondary treatment and chlorination	9
Silver Plume	Clear Creek	Secondary treatment and chlorination	8
Georgetown	Clear Creek	Secondary treatment and chlorination	8
Idaho Springs	Clear Creek	Secondary treatment and chlorination	8
Central City	Clear Creek	Secondary treatment and chlorination	8
Golden	Clear Creek	Plant providing secondary treatment and chlorination	6
Westminster	Clear Creek	Secondary settling and chlorination	8
Wheatridge	Clear Creek	Provide secondary settling and chlorination	8
Arvada	Clear Creek	Secondary treatment and chlorination	8
Longmont	St.Vrain Cr.	Secondary settling and chlorination	8
Boulder	Boulder Cr.	Secondary treatment and chlorination	6
Lafayette	Coal Creek	Secondary treatment and chlorination	8
Estes Park	Thompson R.	Secondary settling and improved chlorination	8
Bureau of Reclamation Camp	Thompson R.	Secondary settling and improved chlorination	8

Table 38 (Continued)

Community	Drainage Basin	Needs	Status*
Colorado(Ct'd)			
Loveland	Thompson R.	(a) New plant needs chlorination	8
		(b) Old plant needs better operation, secondary settling and chlorination	8
Milliken	Thompson R.	Plant providing secondary treatment and chlorination	8
Berthoud	L.Thompson	Better operation, secondary settling and chlorination	8
Johnstown	L.Thompson	Plant providing secondary treatment and chlorination	8
Ft. Collins	Cache la Poudre	Chlorination	8
Windsor	Cache la Poudre	Secondary settling and chlorination	8
Eaton	Cache la Poudre	Replace plant and provide secondary treatment and chlorination	8
Greeley	Cache la Poudre	Increase capacity; secondary treatment and chlorination	8
Wellington	Boxelder Cr.	Secondary treatment and chlorination	8
Nebraska			
Ogallala	S.Platte R.	Restore existing treatment plant and provide chlorination	6
North Platte	S.Platte R.	Effective treatment including chlorination	8
Kimball	LodgepoleCr.	Better operation, improve secondary settling, provide chlorination	8
Sidney	Lodgepole Cr.	Chlorination	8
Chappell	Lodgepole Cr.	Increased capacity, secondary treatment and chlorination	6
Wyoming			
Ft. Warren	Crow Creek	Chlorination	8
Cheyenne	Crow Creek	Plant providing secondary treatment and chlorination	2**

* Status

1. Control or plant adequate.
2. Construction under way.
3. Plans approved - finance arranged.
4. Plans approved - finance not arranged.
5. Plans submitted; approval pending.
6. Plans or report.
7. Under notice or order; no progress known.
8. Project needed; no program known.
9. Status not known.

** Started during 1951.

Table 39 - Pollution Abatement Project Needs

Requirements	Municipal		Industrial
	Number	Population Served	Number
New Plant	15	40,800	38[a]
Enlargement or Additions	22	508,000	0
Replace Existing Plant	3	4,960	6
No Project Required	10[b]	53,200	17
Undetermined	0	-	42

[a] Figures for plants discharging wastes separately; some of these plants could discharge wastes to municipal systems.

[b] Need for chlorinating effluents not considered.

Advisory Committee - Public Hearings

The State of Colorado has recently appointed an Advisory Committee on Stream Pollution to the State Board of Health. This committee has representation from public and private agencies and organizations and from industries which have substantial interest in water pollution control. The function of the advisory committee is to assist the State Board of Health in formulating an adequate water pollution control program for the State, in so far as it affects public health. Committees of this nature can be instrumental in the conduct of public hearings regarding water pollution control problems. Public hearings are advantageous in that they may be the means of bringing water pollution control needs to the attention of the general public and in airing the various sides of the problems so as to make known the complexities which exist. Further, public hearings provide a sounding board for public opinion and give all parties a chance to express their views.

Stream Classifications

The classification of streams in accordance with major water use is an important consideration. Water uses established during previous eras of settlement and industrial development have automatically divided the streams into various spheres of water use. These divisions have been brought about by the establishment of population centers, industries, and agriculture within certain regions along the streams. The waters have long ago been allocated for use within this pattern of settlement and development. Correction of stream abuses which will eventually adversely affect the economy is now in order. This can be accomplished, in time, by concerted action on the part of public and private organizations to maintain their water resources in the best possible condition consistent with accepted downstream use. Further, new installations of all types should be required to provide adequate waste elimination or disposal facilities, consistent with water use, as a prerequisite to their establishment. Such approach to water pollution control in the basin is feasible and practical. It cannot be carried out in a short time, and it will require the expenditure of considerable money and effort before maximum benefits are attained. Complete restoration of all streams in the basin to their pristine condition cannot be achieved. In fact, this would not be desirable in the light of the over-all economic benefits gained by the productive use of these waters.

Streams for Recreational Use

Recreational values can be maintained by reserving certain streams for recreational use and by the regulation of waste discharges to these streams consistent with such use. In addition to game fishing in many of the mountain streams, there is considerable sport in so-called "warm water" fishing. The stocking of larger irrigation reservoirs with self-propagating fish is a recreational asset where reservoir operation is such as to provide for sufficient residual water during the irrigation season to permit fish maintenance and survival. Water for storage in such reservoirs must be of a quality which would permit survival of the aquatic life. The filling of reservoirs with waters containing large volumes of organic wastes will not permit such survival. Provisions must be made to prevent loss of fish through reservoir outlets. Where water for storage is of acceptable quality, and the reservoir conditions are otherwise satisfactory, the establishment of recreational "islands" in various portions of the lower basin would appear to be feasible.

Streams for Public Water Supply

Catchment areas reserved for public water supply purposes require careful control. Watershed restrictions in these cases should be based upon rigid control of the raw water quality as delivered to the treatment plants. No developments should be permitted on the watershed which would cause water pollution to an extent not compatible with the maintenance of an acceptable standard of raw water quality. Rigid requirements for adequate sewage and waste treatment before discharge to the streams are essential in such cases. The actual degree of such treatment

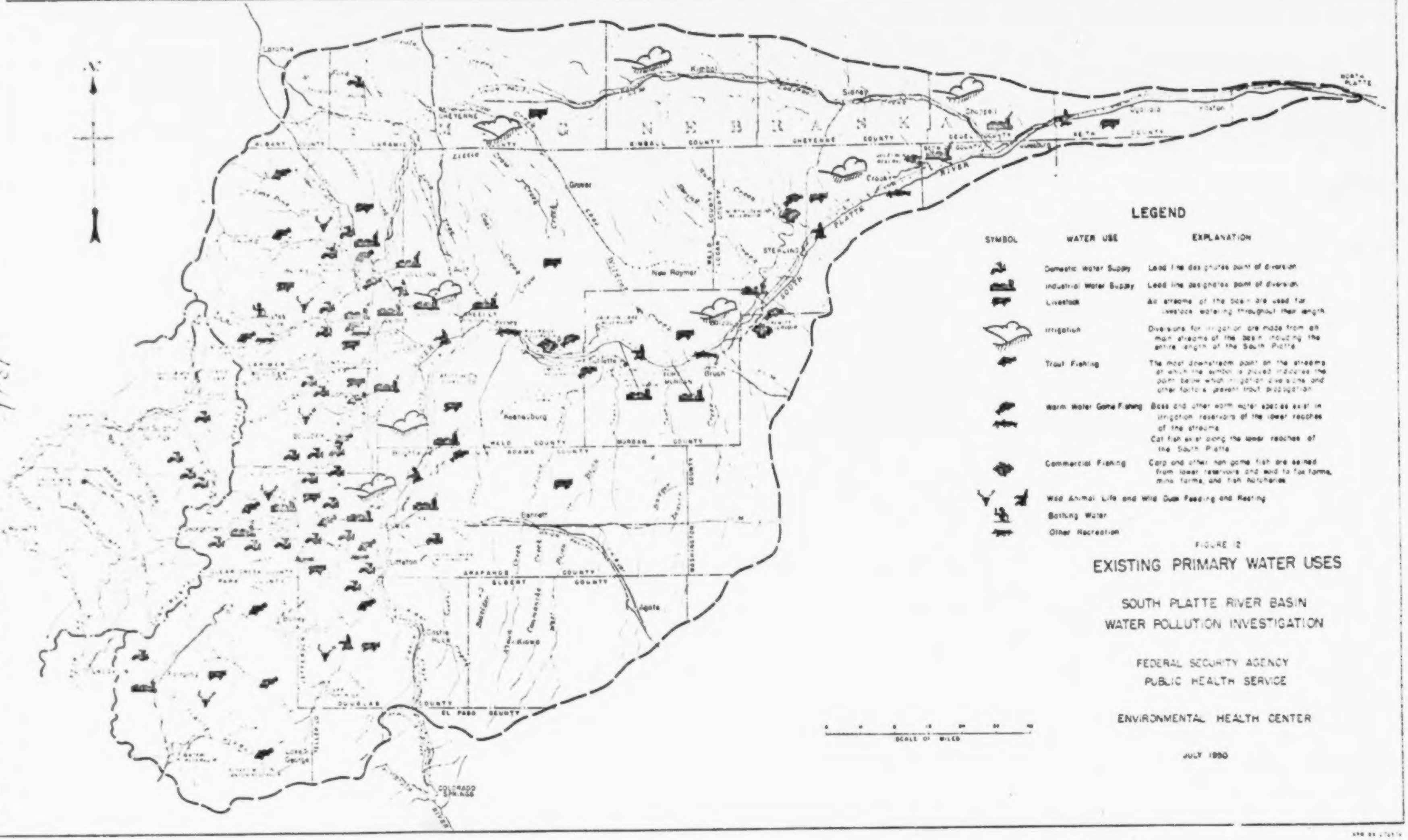
N
NEBRASKA
Laramie
Cheyenne
Kimball
Sidney
Chappell
Julesburg
Ogallala
Paxton
NORTH PLATTE
SOUTH PLATTE RIVER
Sterling
New Raymer
Grover
Crow Creek
Brush
Keenesburg
Bennett
Littleton
Castle Rock
Kiowa
Agate
Lake George
COLORADO SPRINGS
ALBANY COUNTY
LARAMIE COUNTY
KIMBALL COUNTY
CHEYENNE COUNTY
DEUEL COUNTY
KEITH COUNTY
WELD COUNTY
LOGAN COUNTY
MORGAN COUNTY
WASHINGTON COUNTY
ADAMS COUNTY
ARAPAHOE COUNTY
ELBERT COUNTY
DOUGLAS COUNTY
EL PASO COUNTY
LEGEND
SYMBOL
WATER USE
EXPLANATION
Domestic Water Supply
Lead line designates point of diversion
Industrial Water Supply
Lead line designates point of diversion
Livestock
All streams of the basin are used for livestock watering throughout their length
Irrigation
Diversions for irrigation are made from all main streams of the basin including the entire length of the South Platte
Trout Fishing
The most downstream point on the streams at which the symbol is placed indicates the point below which irrigation diversions and other factors prevent trout propagation
Warm Water Game Fishing
Bass and other warm water species exist in irrigation reservoirs of the lower reaches of the streams
Cat fish exist along the lower reaches of the South Platte
Commercial Fishing
Carp and other non game fish are seined from lower reservoirs and sold to fox farms, mink farms, and fish hatcheries
Wild Animal Life and Wild Duck Feeding and Resting
Bathing Water
Other Recreation
SCALE OF MILES

FIGURE 12

EXISTING PRIMARY WATER USES

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER

JULY 1950

would depend upon the location of the point of waste discharge with respect to the water plant intake and upon the physical conditions intervening.

Streams for Irrigation

A major water use in the South Platte River Basin is irrigation. The keystone of the basin economy has been agriculture. In this region a well diversified agriculture is based upon the availability of water for irrigation. That this water should be of a quality suitable for this and other agricultural needs is obvious. The responsibility for maintaining suitable water quality rests to a great extent with the communities and the industries in the basin. Serious economic loss could result from a public boycott of irrigated crops because of a potential health hazard associated with the use of contaminated water for irrigation. The discharge of raw sewage should never be permitted where the receiving waters are to be used subsequently for irrigation. The possibility of bacterial or parasitic contamination of edible crops is real. In view of this fact, it is necessary to be cautious in establishing requirements as to the degree of waste treatment needed. In much of the basin area there is no available surface water which does not contain some sewage discharges. Where this water is used for irrigation of edible crops, insistence upon adequate chlorination of treatment plant effluents is a reasonable requirement. High coliform counts found throughout most of the agricultural region of the basin indicate the need for chlorination.

Streams for Industrial Water Supply

The degree of pollution permissible in waters used for industrial purposes will depend upon the requirements of the industry. Substances which would cause foaming, incrustations, or serious corrosion would not be suitable for boiler or heat exchange purposes. On the other hand, reclaimed sewage waters after adequate treatment are used without difficulty for industrial purposes, including cooling. Process waters used in canning or other food or drink preparations would need to be of drinking water quality.

SOUTH PLATTE RIVER

MAIN STEM AND MINOR TRIBUTARIES

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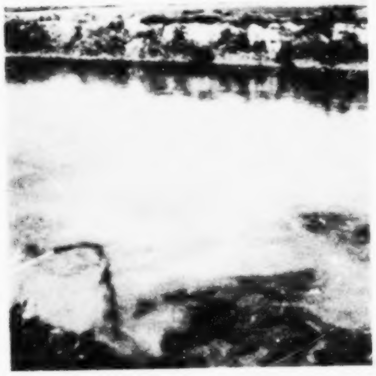
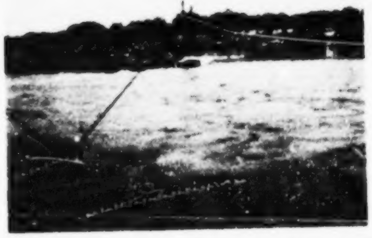
South Platte River
Station 307, Near Denver.
Flood Stage
June, 1949

South Platte River
Station 307, Near Denver
Low Water
December, 1949

South Platte River
Station 57.7, Near
Ogallala, Nebr.
May, 1949



Burlington O'Brian
Canal, About 0.5
Miles Below Intake.
Heavy Oil on Water



Burlington-O'Brian Canal Intake
South Platte River-Station 299
Flood Stage
June, 1949

Burlington O'Brian Canal Intake
South Platte River-Station 299
Low Water
December, 1949

SOUTH PLATTE RIVER - MAIN STEM AND MINOR TRIBUTARIES

SYLLABUS

The main stem of the South Platte River rises in the mountainous South Park Area of Colorado and flows for some 440 miles to its junction with the North Platte River at North Platte, Nebraska. The entire drainage area is 24,030 square miles, of which 19,748 may be considered as the watershed of the main stem and its minor tributaries.

There are seven communities along the South Platte and its minor tributaries using surface water as sources of public water supply. These systems serve an aggregate of 520,000 persons, 481,000 of which are served by the Denver supply. Except for Cheyenne, Wyoming, the remainder are small supplies. The major supplies provide adequate filtration before use of the water in the system.

There are 35 communities serving approximately 54,000 persons using ground water sources for public water supply. Only two supplies serving an aggregate of 8,100 persons receive treatment before use.

Sources of pollution along the main stem and its minor tributaries contribute wastes with an estimated population equivalent of 2,300,000 to the main stream and its minor tributaries. Of this number, 1,530,000 are attributed to seasonal wastes largely from sugar beet processing. Excluding the beet sugar wastes, the population equivalent tributary to the streams is 788,000, of which Denver accounts for 633,000. The wastes from 116,000 population equivalent is discharged to the streams without treatment; that from 641,000, including Denver, receives primary treatment which reduces the load to 368,000 at discharge; and that from an equivalent population of 30,700 receives some type of secondary treatment which reduces the loading to 6,000 at discharge to the streams.

Major water usage is for irrigation purposes. The quality of the water below communities is affected by wastes discharged to the streams as evidenced by laboratory results, especially in the winter months.

Water quality in the headwater streams above Denver appears good. Recreational use is made of the watershed area in the headwaters streams above Denver. It is important that enforcement be continued to prevent undue pollution of the watershed.

It is anticipated that additional stream flows would be available in the South Platte above Denver if the proposed Blue-South Platte Project were authorized for construction. The amounts anticipated as sustained low flows, while resulting in some intangible benefits, especially in the winter months, do not obviate the current need for a higher degree of sewage treatment at Denver.

Minimum flows anticipated in the main stem resulting from operation of the Colorado-Big Thompson Project will exceed those found under present conditions. As these flows will result largely from return flows, the estimated volumes are as yet a matter of conjecture.

It is not anticipated that low-flow increases will materially affect the current need for industrial wastes treatment. Further, the magnitudes of the wastes loads preclude sufficient dilution from anticipated low-flow increases from return flows to the streams. Neither do anticipated low-flow increases obviate the need for adequate sewage treatment or for chlorination of sewage effluents where waters are used for irrigation purposes.

CONCLUSIONS

1. Surface water sources are used by seven communities on the South Platte and minor tributaries. With the exception of Denver, Colorado, and Cheyenne, Wyoming, all of the supplies are for small communities.

2. Ground water sources are used by 35 communities in the area under consideration. These supplies serve an aggregate of 54,000 persons.

3. Sewered communities with an estimated population equivalent load of 788,000 discharge wastes to the streams under consideration. About 15% of this receives no treatment; about 81% is subject to primary treatment; and about 4% of the total loading is subject to secondary treatment.

4. Industrial wastes with an estimated population equivalent of about 1,800,000 are discharged into the streams under consideration. Most of this load is due to seasonal sugar beet processing in the late fall.

5. Water quality in the streams above Denver is good. The streams reflect the discharges of large volumes of wastes below such sources of pollution as Denver, Cheyenne, and sugar beet factories. This is confirmed by laboratory data.

6. Major water usage is for irrigation purposes. The quality of water used for this purpose is deteriorated below sources of pollution.

7. In the event water releases from the Blue-South Platte Project (as contemplated at Denver) become available, intangible benefits will accrue during the greater part of the year. However, during the late spring and early summer, the anticipated flows will be less than those now available. The section of the main river between the Poudre and the Narrows will receive intangible low-flow increase benefits from operation of the Colorado-Big Thompson Project. The Narrows Reservoir Project operations would greatly increase the low summer flows below the reservoir but would reduce the winter flows above Balzac. The general effect of the three projects would be to stabilize flows between Balzac and Julesburg.

RECOMMENDATIONS

1. Communities using untreated surface water supplies should provide for treatment as necessary to assure a uniformly safe palatable water supply.

2. Water quality should be protected to the extent required for reasonable water use by provision, as necessary, of sewage treatment, including adequate chlorination.

3. Adequate waste treatment or reduction, or both, should be provided for industrial wastes, including oil and grease wastes, as necessary to protect downstream water quality and use.

4. Provision should be made to insure adequate waste treatment in those stream areas used as sources of water supply. Strict supervision of the waste discharges into these waters should be maintained.

5. Secondary sewage treatment plants without tanks for final settling should install such equipment in order to improve the over-all plant efficiencies.

(For detailed recommendations regarding municipal sewage treatment needs, refer to Table 38, page 131).

SOUTH PLATTE RIVER

MAIN STEM AND MINOR TRIBUTARIES

DESCRIPTION

The main stem of the South Platte River rises in the precipitous mountains of the Continental Divide bordering the South Park Area of Colorado. It flows in a southeasterly direction through the South Park to the outlet of Elevenmile Reservoir, beyond which point the stream turns sharply to the north and flows through a rugged mountain area to Waterton, Colorado, where it emerges from Platte Canyon and enters the plains area. From this point the stream continues to flow generally northward paralleling the mountains to its junction with the St. Vrain north of Denver. The stream then turns eastward and flows a northeasterly course to its junction with the Cache la Poudre near Greeley. Hence, the stream course is more or less easterly beyond Ft. Morgan, Colorado, whence the stream flows in a general northeast course to the Colorado-Nebraska line, and hence easterly to its junction with the North Platte River at North Platte, Nebraska.

Minor tributaries included in this discussion of the main stem include the following:

Table SP-1 Drainage Areas - Minor Tributaries

Tributary	Drainage Area Sq. Mi.	Point of Junction with South Platte River Mileage from Mouth
South Fork	225	S.P. 402.3
Tarryall Creek	460	S.P. 363.7
North Fork	484	S.P. 335.6
Plum Creek	324	S.P. 320.9
Bear Creek	265	S.P. 311.3
Cherry Creek	414	S.P. 302.8
Crow Creek	1,515	S.P. 227.8
Kiowa Creek	760	S.P. 203.0
Bijou Creek	1,462	S.P. 189.5
Beaver Creek	1,301	S.P. 170.4
Lodgepole Creek	3,101	S.P. 90.0

Elevations along the main stream vary from 10,000 to 13,000 feet in the South Park area, to 5,000 feet in the vicinity of Denver, and 2,800 feet at its confluence with the North Platte in Nebraska. Stream slopes on the main stem vary from several hundred feet per mile near the source to about 7 feet per mile from Kersey to the mouth. Slopes in the Denver area range from 10 to 14 feet per mile. More detailed information is presented in Table 4.

Annual rainfall along the main stem varies from 10 to 14 inches. Air temperatures have a wide range from maxima of well over 100 degrees F. in the summer to minima of -40 degrees F. in the winter months. Highest and lowest temperatures are recorded on the plains area with less variation in the higher elevations.

Relative humidity is generally of a low order and strong, dry winds are general over the basin. Dust storms are common during extended dry periods in the southeastern portion of the basin.

Evaporation ranges from about one inch in the winter to over six inches in the summer.

PRESENTATION OF DATA

Public Water Supplies

Denver is the only community obtaining its public water supply directly from the South Platte River. Pertinent features of the Denver Water Supply are shown in Figure SP-1. The main South Platte watershed utilized by the city covers an area of about 3,910 square miles and extends to a point about 125 miles above Denver. Water is taken from the stream near the mouth of Platte Canyon about 23 miles above the city. Additional amounts of water are taken from Bear Creek and Cherry Creek, the latter by means of an infiltration gallery. In 1936 the Denver supply was augmented by importation of water from the western slope through the Moffat Tunnel. At the present time, about 60% of the Denver supply is obtained from the South Platte, 30% from the transmontane diversion, and about 10% from Bear Creek and Cherry Creek sources. Current water consumption averages about 88.6 MGD. Total rated filter plant capacity is 186 MGD.

Table SP-2 Denver Water Supply Reservoirs

Reservoir	Capacity Acre-Feet
Storage Reservoirs	
Antero (City owns 66% of water)	33,276
Elevenmile Canyon	81,917
Cheesman	79,064
Soda Lakes (City owns 30% of water)	2,005
Operating Reservoirs	
Marston Lake	19,793
Ralston	12,000
Platte Canyon	905

Filter plant capacity is divided among 5 filter plants. These plants and their capacities are as follows:

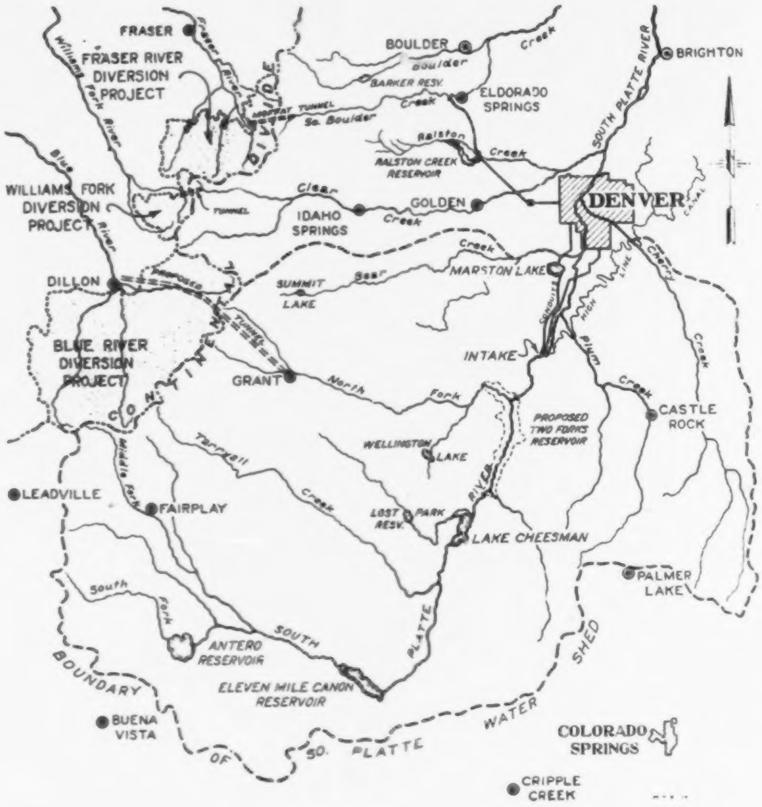


FIGURE SP-1

GENERAL MAP OF ENTIRE DENVER WATER SYSTEM PRESENT & PROPOSED

SOUTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
APRIL 1949

GPO 83-171976

Table SP-3 **Denver Filter Plants**

Plant	Type	Rated Capacity Gal/Day
Kassler	Slow sand	30,000,000
Willard	Rapid sand	15,000,000
Marston Lake, South	Rapid sand	21,000,000
Marston Lake, North	Rapid sand	64,000,000
Moffat	Rapid sand	56,000,000

In order to provide for future growth of the city, a diversion project is underway to construct a tunnel to the Blue River on the western slope of the Divide. This tunnel will become a portion of the Blue-South Platte Project of the Bureau of Reclamation and will supply the city with 46,000 acre-feet of additional water annually if the project is constructed as proposed.

There are 6 other communities on the South Platte or minor tributaries which use surface waters as sources of public water supplies. These communities serve an estimated aggregate of 39,200 persons, of which about 35,000 are located in Cheyenne, Wyoming. All of these communities derive their supplies from sources which are subject to relatively little pollution. Thirty-five communities serving an estimated 53,950 persons utilize ground water sources for their water supplies as shown in Table SP-5.

Table SP-4 **Surface Water Supplies**
Main Stem and Minor Tributaries

Community	Watershed	Source	Est. Pop. Served 1949	Treatment	Rated Capacity MGD*
Colorado:					
Fairplay	So. Platte R.	Beaver Cr. Spring	800	None	0.25
Littleton	So. Platte R.	Infiltration	2,500	Disinfection	--
Denver	So. Platte R.	Impoundment	481,000	Rapid sand filter-disinfection	189.0
Evergreen	Bear Creek	Bear Cr.	350	Pressure filters-disinfection	0.20
Morrison	Bear Creek	Bear Cr.	250	Zeolite filters-disinfection	0.25
Palmer Lake	Plum Creek	Impounded Thompson Cr.	270	None	0.25
Wyoming:					
Cheyenne	Crow Creek	Crow Creek Impounded	35,000	Rapid sand filters disinfection	12.0

* MGD = Million gallons per day

Table SP-5

Ground Water Supplies
Main Stem and Minor Tributaries

Community	Watershed	Source	Est. Pop. Served 1949	Treatment	Rated Capacity MGD*
Colorado:					
Brighton	So. Platte	Wells	4,200	None	1.5
Ft. Lupton	So. Platte	Wells	1,700	None	0.65
Platteville	So. Platte	Wells	600	None	0.25
LaSalle	So. Platte	Wells	800	None	1.15
Evans	So. Platte	Greeley	800	None	0.10
Kersey	So. Platte	Well	300	None	0.05
Ft. Morgan	So. Platte	Deep Well	5,000	None	2.0
Brush	Beaver Cr.	Wells	2,550	None	1.0
Merino	So. Platte	Wells	240	None	0.5
Sterling	So. Platte	Wells	7,500	Disinfection	3.0
Iliff	So. Platte	Deep Wells	300	None	0.1
Crook	So. Platte	Shallow Well	250	None	0.06
Sedgwick	So. Platte	Well	350	None	0.25
Ovid	So. Platte	Shallow Wells	700	None	0.10
Julesburg	So. Platte	Wells	1,800	None	0.50
Castle Rock	Plum Creek	Shallow Wells	600	None	1.0
Wellington	Boxelder Cr.	Shallow Wells	400	Disinfectio	0.25
Ault	Lonetree Cr.	Wells	780	None	0.15
Eaton	Lonetree Cr.	Shallow Well	1,530	None	0.75
Nunn	Lonetree Cr.	Well	180	None	0.10
Pierce	Lonetree Cr.	Well	350	None	0.05
Hudson	Boxelder Cr.	Well	400	None	0.15
Keenesburg	Boxelder Cr.	Deep Well	300	Disinfection	0.10
Deer Trail	Bijou Cr.	Deep Well	450	None	0.10
Peetz	--	Well	210	None	0.10
Nebraska:					
Big Springs	So. Platte	Wells	500	None	0.90
Ogallala	So. Platte	Deep Wells	2,000	None	1.50
Paxton	So. Platte	Deep Wells	460	None	0.77
North Platte	So. Platte	Wells	12,000	None	7.33
Bushnell	Lodgepole Cr.	Deep Well	200	None	0.38
Kimball	Lodgepole Cr.	Wells	1,600	None	1.0
Dix	Lodgepole Cr.	Deep Well	150	None	0.02
Potter	Lodgepole Cr.	Wells	300	None	0.86
Sidney	Lodgepole Cr.	Wells	3,450	None	2.33
Chappell	Lodgepole Cr.	Wells	1,000	None	0.97

* MGD = Million gallons per day

Sources of Pollution

Table SP-6 summarizes the magnitude and location of significant sources of pollution discharged to the main stem and to minor tributaries of the South Platte River. Industrial wastes from seasonal beet sugar operations have been separated from other wastes so as to emphasize their importance and allow analysis of the remainder of the pollution load on the basis of treatment provided. The total population equivalent of the untreated wastes of communities and industries along the main stem and minor tributaries is estimated at approximately 2,300,000. Of this number, 1,530,000 are attributable to wastes from beet sugar processing. The population equivalent, excluding this seasonal loading, would be about 788,000, of which the City of Denver accounts for 633,000, or over 85%. This leaves a total raw waste equivalent of about 155,000 for all remaining communities and industries along the main stem and minor tributaries.

The total population equivalent as discharged to the streams is estimated as 2,020,000, of which 372,000 is contributed by the City of Denver and 1,530,000 is due to seasonal beet sugar wastes. Exclusive of beet wastes, the wastes from about 116,000 population equivalent (including Cheyenne) are discharged without treatment. The sewage from about 641,000 population equivalent, including Denver, receives primary treatment which reduces this figure to an estimated 368,000 at discharge. Wastes from an equivalent population of about 30,700 receive some type of secondary treatment which reduces the loading to an estimated 6,000 as discharged to the streams. Excluding the seasonal industrial waste loading which accounts for 66% of the untreated population equivalent, about 15% of the wastes are discharged without treatment.

About 81% of the population equivalent (excluding beet sugar wastes) receives only primary treatment before discharge to the streams. About 4% is given secondary treatment. At some of the secondary treatment plants, failure to provide for secondary settling reduces the efficiency of the secondary treatment in that humus from the trickling filters is discharged to the stream with the plant effluent. Table SP-8 shows the amount of the water consumption returned to sewers by the City of Denver. Table SP-9 shows the monthly summary of B.O.D. of the influent and effluent of the main Denver sewage treatment plant for 1948-1949. Figure 4 shows graphically the results of a study of daily variations in B.O.D., flow, and stream data at the Denver sewage treatment plant. The estimate of the population equivalent (580,000) of the raw sewage received at the main Denver plant was based on the average of city data for 1949. (See Table SP-9). To this value was added a population equivalent of 30,000 as an allowance for independent untreated industrial (12 plants) and other waste discharges originating within Denver. (See page 148). In estimating the reduction in population equivalent effected by treatment at the main plant, a 43% removal was assumed, based upon average results for 1949 as reported by the City.

Table SP-6

Summary of Sources of Pollution

Community	Stream	River Mileage Above Mouth	Sewered Population	Treatment (1)	Estimated Population Equiv. Based on BOD	
					Untreated	Discharged
Colorado						
Castle Rock	Plum Creek	SP-P 29.3	580	P	580	405
Littleton	So. Platte River	SP 314.2	2,660	S	2,660	1,000
Federal Correctional Institution	Bear Creek	SP-Be 8.5	500	S	500	200[a]
Ft. Logan	Bear Creek	SP-Be 3.0	3,000	S	3,000	300
Denver	(1) So. Platte	SP 299.2	425,000	P	610,000	360,000
	(2) Sand Creek	SP-Sa 5.4	15,000	P	23,000	12,000
Industrial Wastes	Burl-O'Brian Canal	SP-B-O'B 1.2 - 1.6	--	None	12,600	12,600
Buckley Field	Sand Creek	SP-Sa 11	1,900	S	1,900	400
Fitzsimons Hospital	Toll Gate Creek	SP-Sa-T 1.2	5,000	S	5,000	250
Aurora	Sand Creek	SP-Sa 5.8	5,500	P	5,500	3,850
Industrial Wastes	Sand Creek	SP-Sa 1.0	--	None	2,700	2,700
Industrial Wastes	So. Platte River	SP-298.6 - 297.5	--	P - None	13,740	11,340
Brighton (Sewage)	So. Platte River	SP-284.0	4,500	S	4,500	1,800[a]
Industrial Wastes	So. Platte River	SP-283.6	--	None	7,500	7,500[b]
Industrial Waste	So. Platte River	SP-283.9	--	None	180,000	180,000[d]
Ft. Lupton	So. Platte River	SP-272.2	1,700	P	5,400	3,800
Platteville	So. Platte River	SP-260.0	700	None	700	700
LaSalle	So. Platte River	SP-239.8	1,000	P[c]	1,000	800
Evans	So. Platte River	SP-239.8	250	(g)	250	180
Deer Trail	Bijou Creek	SP-Bi 65	450	None	450	450
Ft. Morgan (Sewage)	So. Platte River	SP-184.6	6,000	P	6,000	4,370
Industrial Waste	So. Platte River	SP-184.0	--	None	450,000	450,000[d]
Brush (Sewage)	So. Platte River	SP-173.8	3,000	P	3,000	2,250
Industrial Waste	Beaver Creek	SP-Bea 6.0	--	None	250,000	250,000[d]
Merino	So. Platte River	SP-166.8	200	None	200	200
Sterling (Sewage)	So. Platte River	SP-153.0	8,000	P	8,000	5,200
Industrial Waste	So. Platte River	SP-153.0	--	None	360,000	360,000[d]

Table SP-6 (Continued)

Community	Stream	River Mileage Above Mouth	Sewered Population	Treatment (1)	Estimated Population Equiv. Based on BOD	
					Untreated	Discharged
Nebraska						
Kimball	Lodgepole Creek	SP-Lod 101.0	2,000	S	2,000	400
Sidney	Lodgepole Creek	SP-Lod 55.7	4,000	S	5,500	1,100
Chappell	Lodgepole Creek	SP-Lod 12.0	1,000	P	1,250	885
Colorado						
Ovid (Sewage)	Lodgepole Creek	SP-Lod 0.2	600	None	600	600
Industrial Waste	Lodgepole Creek	SP-Lod 0.2	--	None	290,000	290,000[d]
Julesburg	So. Platte River	SP-90.0	1,800	None	1,800	1,800
Nebraska						
Ogallala	So. Platte River	SP-57.2	4,600	None[e]	4,600	4,600
North Platte	So. Platte River	SP-2.5	5,700[e]	None	6,900[f]	6,900
Wyoming						
Cheyenne	Crow Creek	SP-Cr 76.0	35,000	Lagoons[h]	35,000	35,000
Industrial Waste	Crow Creek	SP-Cr 76.0	--	None	6,300	6,300
Ft. Warren	Crow Creek	SP-Cr 81.0	5,600	S	5,600	560

(1) P - Primary Treatment. S - Secondary Treatment.

a No secondary settling provided.
b Seasonal operations May-December.
c Septic Tank.
d Seasonal October-December.
e Existing secondary treatment plant not in use.
f Estimated tributary to South Platte River.
g Individual septic tanks discharging to storm sewer.
h Construction of a secondary treatment plant started during 1951.

Industrial waste loading summary for the main stream and its minor tributaries is shown in Table SP-7, below.

Table SP-7 - Industrial Plants Contributing Organic Wastes into the South Platte River and Minor Tributaries

Type of Industry	Number of Plants	Population Equivalent BOD Basis
Paper Mill	1	7,800
Meat Packing	7	11,950
Rendering	1	750
Dairy Products:		
Fluid Milk	11	2,850
Canneries	1	210
Cheese	1	100
Food Processing Except Milk:		
Canneries	3	9,700
Beet Sugar Factories	5	1,530,000
Oil Refineries	5	13,800
Denver Industries[a] (tributary to Denver treatment plants)	156	163,000[b]
Denver Industries[a] (Direct discharge of all or part of wastes to stream)	11	20,000*
Denver vicinity (Miscellaneous sources of pollution including Bear Creek and city dump** at 31st Ave.)	-	10,000*

[a] See industrial waste section of General Data Division.

[b] This figure was obtained by subtracting the estimated population of 440,000 from the B.O.D. population equivalent of 603,000.

* The direct discharge of organic wastes to the South Platte River is shown by the B.O.D. increase in the stream between the Littleton, Colorado (SP 314.4) and the 40th Street sampling station (SP 300.0) above the point of entry of the Denver city sewage. The pollution gain between these points from all sources represents a population equivalent of approximately 30,000. As of September, 1949, drainage from a city-operated dump located at 31st Avenue and the South Platte River was contributing organic pollution having a population equivalent of 5,500 (B.O.D. basis).

** Editorial Note: Since completion of this survey, water pollution from this source has been eliminated. (See page 250, also).

Table SP-8 Annual Return Flow to South Platte River Through Denver Sanitary and Storm Sewers 1927 - 1949

Year	City Consumption Filtered Water Ac.-Ft.	Return thru Sanitary Sewers Ac.-Ft.	% Return Sanitary Sewers	Return thru Storm Sewers Ac.-Ft.	% Return Storm Sewers
1927	68,222	52,595	77.1	No record	No record
1928	73,506	53,181	72.3	No record	No record
1929	69,040	53,143	77.0	No record	No record
1930	76,201	51,103	67.0	No record	No record
1931	75,772	50,614	66.8	4,690	6.2
1932	70,890	48,464	68.4	4,972	7.0
1933	65,976	46,276	70.1	6,368	9.6
1934	69,356	42,671	61.5	4,018	5.8
1935	58,310	41,648	71.4	3,588	6.2
1936	64,966	46,593	71.7	3,794	5.8
1937	68,898	47,962	69.6	4,992	7.2
1938	63,539	46,486	73.2	6,748	10.6
1939	78,635	46,964	59.7	7,464	9.5
1940	72,185	51,535	71.4	6,318	8.8
1941	67,820	55,899	82.4	7,378	10.9
1942	79,580	60,523	76.1	6,372	8.0
1943	87,508	59,238	67.7	6,280	7.2
1944	86,474	60,790	70.3	6,472	7.5
1945	79,858	59,669	74.7	6,368	8.0
1946	89,902	62,582	69,6	6,228	6.9
1947	90,382	68,788	76.1	6,194	6.9
1948	102,198	69,694	68.2	6,150	6.0
1949	99,622	73,281	73.6	5,482	5.5

Taken from the 1949 Report of the Denver Board of Water Commissioners.

Table SP-9 **Monthly Average Flow and BOD of Denver Sewage 1948-1949**

(City Sewage Treatment Plant Data)

Month	Flow MGD		5-Day BOD Raw Sewage		5-day BOD Sewage Effluent		% Reduction	
	1948	1949	1948	1949	1948	1949	1948	1949
Jan.	56.4	54.4	227	245	141	149	38	39
Feb.	57.7	55.5	194	229	133	147	31	36
Mar.	57.6	54.6	230	226	114	125	50	45
Apr.	57.7	54.5	217	204	138	125	36	39
May	61.5	57.5	319	188	185	119	63	37
June	64.9	60.2	207	176	117	122	44	31
July	65.7	58.9	188	210	108	96	43	54
Aug.	65.2	52.5	177	176	100	89	44	49
Sept.	56.2	56.5	174	180	119	101	32	44
Oct.	54.9	59.7	201	196	123	107	39	46
Nov.	55.8	56.9	206	195	124	115	40	41
Dec.	52.6	54.5	242	239	159	104	34	57
Total	706.2	675.7	2582	2464	1561	1399	--	--
Avg.	58.8	56.3	215	205	130	117	40	43

Population Equivalent 1948 Raw = 630,000 Effluent = 380,000
Population Equivalent 1949 Raw = 580,000 Effluent = 330,000

Note: (1) These figures obtained from Records of Denver Sewage Treatment Plant.
(2) No samples of sewage from Saturday or Monday included in averages.

The major industrial waste loading along the main stream outside of the City of Denver is due to sugar beet processing. This is a seasonal load from about October to December of each year. The next heaviest loading is probably the packing industry, the bulk of which is located in Denver and which reaches the stream through the Denver Sewage Treatment Plant. Packing plants discharging raw wastes to the South Platte River immediately below Denver have a total population equivalent of 11,300. Canneries along the main stem also contribute a seasonal pollution load from May to November, the amount of pollution contributed depends upon the item being canned. Items having considerable wet waste, such as pumpkin, squash, and beets produce higher pollution than those with dry wastes such as peas, beans, or cabbage. Two canneries discharge raw wastes to the Ft. Lupton Sewage Treatment Plant, and one discharges raw wastes direct to the South Platte River. Screening of a sort is practiced and solids thus removed are usually carted to dumps or buried.

Laboratory Results

Average results for summer and winter seasons, together with the major sources of pollution, are shown in Figures SP-2, SP-3 and SP-4. The laboratory results covering determinations of dissolved oxygen, B.O.D., and median coliform counts are shown for the main stem only. These data are also shown graphically on Figures 6, 8 and 10 for the summer season (May to September) and on Figures 7, 9 and 11 for the winter season (October to April). The values presented in the figures are averages and do not show the most critical conditions at any given station. For a clearer picture at any given point, reference is made to the Summary of Individual Results appearing in Appendix "J," or to the Summary of Seasonal Results appearing in Table 34 in the General Section.

Dissolved Oxygen

The most critical May-September dissolved oxygen results in the vicinity of Denver were obtained in the Burlington-O'Brian Canal below Denver where at certain times the complete exhaustion of oxygen was found. Under the anaerobic or septic conditions thus indicated, serious odor nuisance conditions are to be expected. The next most critical dissolved oxygen condition was found in the main stem just below Denver where the average oxygen content (May-September) falls below 4 ppm.

In the winter months the oxygen levels show the effects of beet waste discharges with sharp declines in saturation levels on the main stream below its confluence with the St. Vrain, Thompson and Cache la Poudre Rivers, and again below Sterling and Ovid. The winter dissolved oxygen picture is generally less favorable than that for the summer months because of the influence of sugar beet processing and of lower stream flows.

Unfavorable D.O. conditions are found below Cheyenne in Crow Creek because of the discharge of raw sewage which proceeds along the stream to the impoundment used as a lagoon.

Conditions along Lodgepole Creek are generally good with oxygen levels in excess of 5 ppm. Exceptions noted are at the outlet of Oliver Reservoir below Bushnell and Sidney, Nebraska, where unsatisfactory oxygen levels as low as 2 ppm. were noted at times. Lodgepole Creek has erratic stream flows, except in times of heavy runoff and there is little relationship between results at various stations along the stream. The same general statement might be made concerning all streams in the basin, especially during the summer irrigation season. Even in the South Platte there are times when no flow exists in short stream stretches between Denver and Ft. Lupton gage and below major diversions further downstream. At such times there is no relationship between results obtained from a point, say, immediately below Denver and another at, say, Brighton or Ft. Lupton further downstream. These stream stretches of zero flows are usually quite short, as the stream flow builds up rapidly as a result of return flows from drainage ditches and seepage.

B.O.D. Results

B.O.D. results are generally higher during the winter season (October-April) when the wastes from sugar beet processing are being discharged to the streams. Relatively sharp increases in B.O.D. are noted below sources of pollution during the summer season but the magnitude of these increases is much higher during the winter period.

The B.O.D. values in the main stem show a gradual increase through the City of Denver from values of about 1.0 ppm below Littleton and 2.0 ppm near the south city limits to about 6.0 ppm above the main Denver sewage treatment plant. This is indicative of a substantial amount of pollution. Based on individual B.O.D. and stream flow results, the population equivalent of this pollution is estimated at about 30,000. Part of this load is derived from independent waste discharges (See Page 67 and Appendix "C") from industries located in Denver and refuse dump drainage (See Page 148).

Immediately below the Denver outfall the B.O.D. values increase to 60 - 80 ppm on the left bank of the stream, and to 40 - 50 ppm on the right bank opposite the treatment plant. The B.O.D. increases on the right bank were the result of packing house wastes by-passing the city sewers and of a serious break in the outfall sewer during the summer which allowed a large quantity of raw sewage to enter the stream over an extended period. Repairs to the line were completed early in September, 1949.

Unsatisfactory stream conditions below Cheyenne are reflected in the B.O.D. of the samples from above and below the lagoon.

Average B.O.D.'s at stations along Lodgepole Creek gave results of about 5 ppm below Bennett Reservoir near Kimball and below Sidney, Lodgepole and Chappell.

Coliform Results

In general, coliform counts over the entire basin, except in or immediately below the more mountainous regions, were relatively high. Median values of over 20,000 per 100 ml were the rule at the majority of stations both during the summer and winter seasons. Coliform numbers were in general far in excess of the limiting value for irrigation water set by the Colorado State Health Department. While epidemiological data are in general not conclusive with respect to disease transmission resulting from contamination of crops by irrigation waters containing sewage, such high coliform concentrations should be the cause of concern in an area such as that drained by the South Platte River. Throughout much of this area, irrigation of crops with waters from surface streams is of considerable commercial importance.

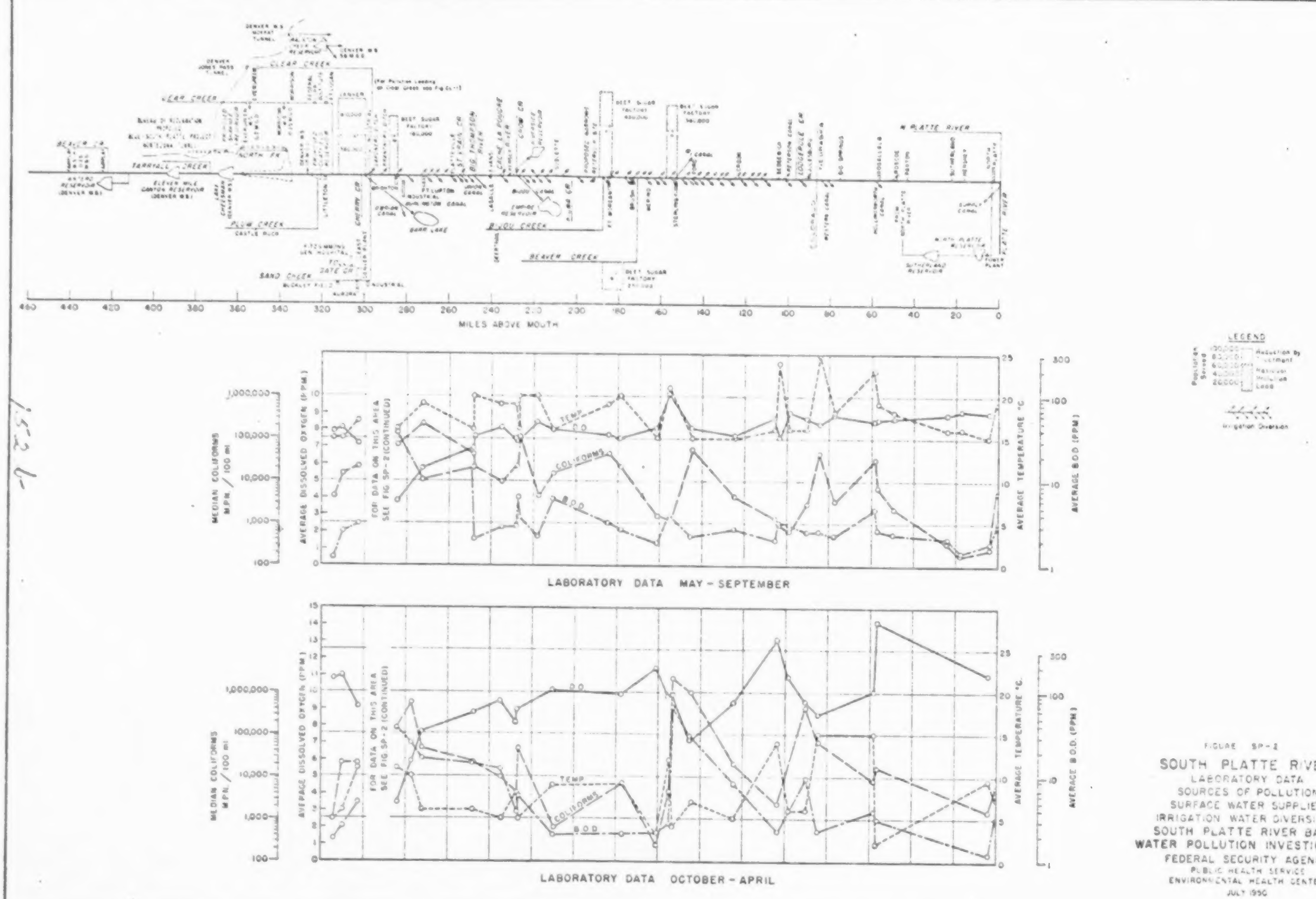


FIGURE SP-2

SOUTH PLATTE RIVER
LABORATORY DATA
SOURCES OF POLLUTION
SURFACE WATER SUPPLIES
IRRIGATION WATER DIVERSIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

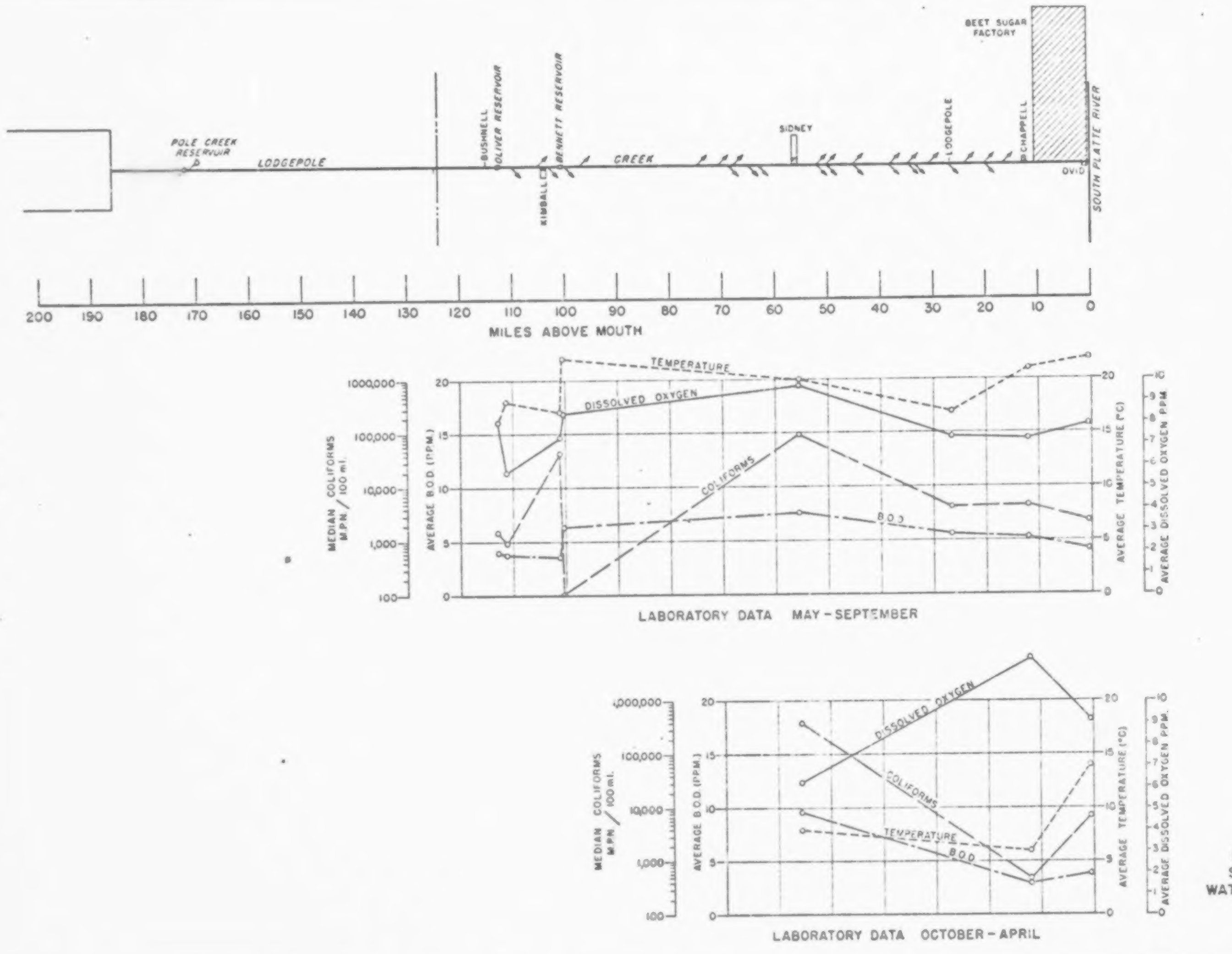


FIGURE SP-3
LODGEPOLE CREEK
LABORATORY DATA
SOURCES OF POLLUTION
SURFACE WATER SUPPLIES
IRRIGATION WATER DIVERSIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

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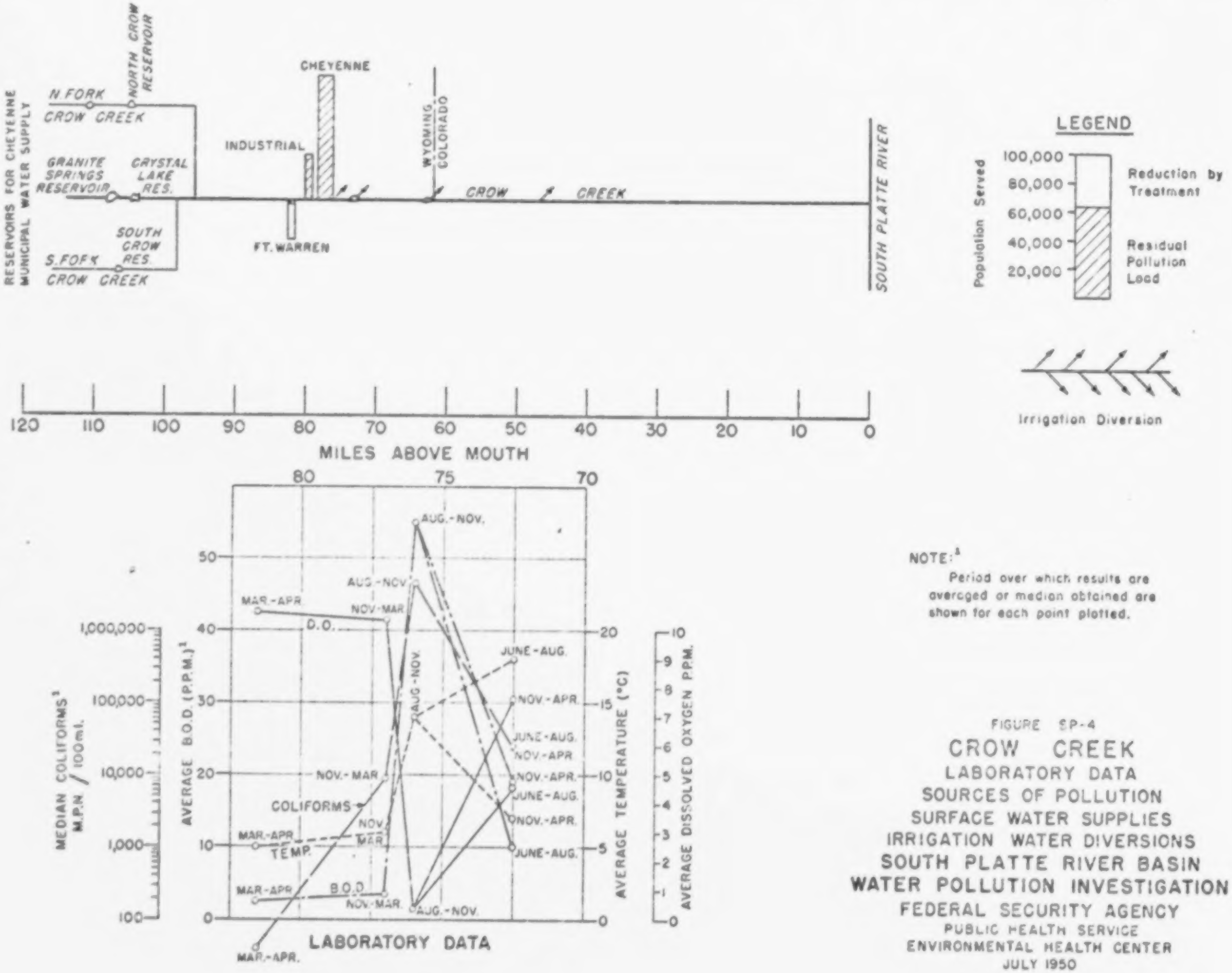

NOTE:¹
Period over which results are averaged or median obtained are shown for each point plotted.

FIGURE SP-4
CROW CREEK
LABORATORY DATA
SOURCES OF POLLUTION
SURFACE WATER SUPPLIES
IRRIGATION WATER DIVERSIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

The magnitude of the median counts was higher during the winter season except below Denver where the break in the outfall sewer to the treatment plant reflects the discharge of considerable raw sewage during the summer. Coliform counts on the right bank opposite the treatment plant are consistently higher than those on the left side of the stream below the plant outfall. This reflects the chlorination of the plant effluent before discharge to the stream. It is interesting to note that the median coliform counts over a large portion of the main stem were in excess of 10,000 per 100 ml during the irrigation season, and that it was only in the lowermost reaches, where irrigation diversions were less numerous, that the counts consistently fell below 1,000 per 100 ml. It may be well to note the fact that the stream between Julesburg and Ogalalla may have zero flows at times during the summer because of irrigation diversions below Julesburg so that results from this point have little effect on the downstream stations.

High coliform counts in Crow Creek below Cheyenne reflect the discharge of raw sewage to the creek.

Sewage from the towns of Kimball and Sidney are reflected in the high coliform counts at the inlet to Bennett Reservoir and below Sidney.

Chemical Results

Copper was investigated because of its effects on the BOD determinations when present in amounts in excess of 0.01 ppm. Maximum copper content of about 0.1 ppm is present in samples above Denver. This figure increases to nearly 0.3 below the Denver sewage treatment plant. Normal values for copper decrease from this point downstream until amounts of from 0.01 to 0.04 are found consistently in samples below the Cache la Poudre.

Hardness has a tendency to increase progressively downstream and is inversely proportional to the stream flow as would be expected.

Low-Flow Frequencies

Table SP-10 summarizes a study of low mean monthly flow frequencies during the period of record for 9 gaging points on the main stem. The periods of record vary from 17 to 53 years. Low flows were computed for the summer period (May to September) and for the winter period (October to April) to correspond roughly to the irrigation and non-irrigation seasons.

Low stream flows are important as they affect the amount of dilution available for wastes discharged to the stream. The available dilution, in turn, has a profound effect upon the degree of waste treatment required so as to prevent nuisance and maintain desirable oxygen levels.

Table SP-10

Low-Flow Frequencies

Gaging Station Location on So. Platte River	Miles above Mouth	Drainage Area in Square Miles	Years of Record	Values in Cubic Feet per Second which the Mean Monthly Flow May Be Expected to Equal or Be Less than on the Average of once in:								Low Mean Month of Record in Cubic Feet per Second	
				2 Years		3 Years		5 Years		10 Years			
				Summer (1)	Winter (1)	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Waterton, Colo.(2)	327.4	2,621	22	81	5.0	62	3.3	47	2.3	35	1.4	23	0.45
Denver, Colo.(3)	302.3	3,840	53	123	62	103	56	88	50	71	40	68	32
Henderson, Colo.	286.7	4,740	22	140	50	121	46	103	42	87	33	67	29
Ft.Lupton, Colo.	272.2	5,070	19	88	83	69	77	58	60	55	48	55	34
Kersey, Colo.	231.9	9,500	44	111	198	100	164	91	130	84	81	67	82
Sublette, Colo.	210.0	12,900	21	148	52	141	49	125	45	107	42	95	37
Balzac, Colo.	164.1	17,700	34	116	12.0	102	10.5	87	9	74	7.2	44	8.1
Julesburg, Colo.	90	22,800	43	19.5	49	15.8	36	12	23	7.5	16	2.2	5.2
No. Platte, Neb.	(4)	24,030	17	0	0	0	0	0	0	0	0	0	0

(1) Summer - Irrigation Season, May 1 to September 30.
Winter - Non-Irrigation Season, October 1 to April 30.

(2) Flow regulated by 3 reservoirs. Diversions for irrigation and for Denver water supply are made above station.

(3) Gaging station is above Denver Sewage Treatment Plant outfall.

(4) Zero flow may be expected in summer from irrigation and in winter from ice condition.

DISCUSSION

Sewage Treatment Status and Needs

The bulk of the raw sewage discharged to the main stem of the South Platte is by communities in the lower portion of the stream and includes Ovid and Julesburg in Colorado, and Ogalalla and North Platte in Nebraska. These communities, together with the small towns of Platteville and Merino in Colorado, make up only a small percentage of the population equivalent discharging wastes into the stream. However, these communities should provide adequate sewage treatment. The City of Ogalalla has a treatment plant built in 1936 which is not being operated. The sewage from this city should receive adequate treatment to eliminate unsatisfactory conditions in the slough by the plant.

Sewage entering the South Platte River from North Platte, Nebraska, represents roughly one-third of the sewered population of that city. The remaining sewage from the city is discharged to the North Platte River. Dilution is afforded the sewage discharged into the South Platte from the Power Canal outlet which contributes 1,000 or more second-feet to the flow of the river. The effects of the discharge of raw sewage into the North Platte are noted by the B.O.D., and the coliform counts of the samples taken at the Supply Canal intake in the Platte River below the junction of the North and South Forks.

The major pollution problem in the main stem is created by the discharge of sewage from the City of Denver. The Denver sewage receives partial treatment consisting of sedimentation plus chlorination. Occasional failures to apply chlorine have been noted. This is a serious shortcoming. Effort should be directed toward the assurance of reliable chlorination. Minimum mean daily discharge at Denver is recorded as 15.0 cfs (Table 9, General Section). The average daily discharge of the Denver sewage treatment plant for 1948 and 1949 was 57.5 M.G.D. (89 cfs). Stream flows recorded for the low mean month of record at Denver are 68 cfs for the summer season (May-September), and 32 cfs for the winter season (October-April). Average discharge for the Denver sewage treatment plant for the same seasons during 1948 and 1949 was 59.9 M.G.D. (92.6 cfs), and 55 9 M.G.D. (86.4 cfs), respectively. Using the minimum mean daily discharge figures for 1948 and 1949, it is possible for the sewage effluent to contribute 85% of the stream flow below the treatment plant. Using the data for low mean monthly flows, during the summer season, 58% of the stream flow below Denver would be plant effluent, and during the winter season 73% of the flow would be effluent. The percentages of plant effluent in the stream under low-flow conditions will increase as the population and industrial development of the city increases. Table SP-11 shows the contribution of Denver sewage to the flow of the South Platte River under maximum, minimum, and average stream flow conditions in 1945, a more or less average year. It will be noted that nearly 70% of the stream runoff under low-flow conditions in January and February was made up of Denver sewage plant effluent. Construction of an enlarged primary treatment plant is under way and should be completed in

Table SP-11

Contribution of Denver Sewage to Flow of South Platte River under Maximum, Minimum, and Average Flow Conditions 1945

Month 1945	Average Sewage Flow 1945 1000 A.F.	Runoff South Platte River 1945 1000 A.F.			Percent Sewage in Flow		
		Max.	Min.	Average	Max. Stream Flow	Min. Stream Flow	Average Stream Flow
January	4.92	25.92	7.02	12.52	19.	70.	28.6
February	4.48	28.28	6.58	11.58	15.8	68.	38.7
March	4.96	61.26	8.26	15.96	8.1	60.	31.5
April	5.12	206.82	9.02	33.32	2.48	56.8	15.9
May	5.31	253.7	15.61	59.71	2.1	35.1	8.89
June	5.25	234.25	16.65	56.25	2.24	31.6	8.79
July	5.51	74.71	12.01	38.51	7.37	45.5	14.3
August	5.3	147.0	12.50	39.70	3.61	42.4	13.3
September	5.76	63.06	10.16	23.08	9.12	56.7	25.0
October	5.74	59.84	9.54	18.84	9.59	60.1	30.5
November	5.54	45.54	10.34	16.34	12.2	53.6	33.9
December	4.77	28.07	8.17	13.67	17.0	58.4	34.9

the summer of 1950. This will relieve the overloading of the present plant and if chlorination is more carefully controlled, the over-all result should be improved efficiency of the treatment process in use. The principal use of the waters immediately below the treatment plant outfall is for irrigation purposes. Results of analyses of samples taken along the Burlington-O'Brian Canal to Barr Lake reveal a heavily polluted stream. Total oxygen depletion occurs in this canal with resultant nuisance conditions. Heavy sludge deposits were noted in the canal near the inlet to Barr Lake. Reductions of B.O.D. and coliform counts are noted in the Barr Lake outlet ditches, especially at the west end of the lake. Dissolved oxygen values are variable, with supersaturation because of algae growths in midsummer.

The water resources in the South Platte Basin are extremely limited. Conservation and re-use of water is a necessity. Sewage treatment is in a sense a conservation measure in that the water may be reclaimed for re-use. As the size of the city increases, the wastes will contribute a larger and larger proportion of the stream flow below the city. It is now necessary to condition the wastes in order to maintain water of reasonably good quality in the stream. This cannot be done satisfactorily by means of primary treatment alone, because the wastes are not sufficiently oxidized to prevent nuisance under certain conditions in the irrigation ditches below the city. Further, chlorination of the treatment plant effluent as currently practiced is not sufficiently reliable to assure a continuous high level of efficiency. The Denver treatment plant is undergoing a reconstruction which will increase its primary treatment capacity. It is expected that the additional capacity will improve the efficiency of treatment now being obtained at the Denver plant. However, the plant is still a primary treatment process and, as such, is limited to the removal of suspended materials. Even if the plant were 100 per cent efficient, dissolved substances which require a different type of treatment for their removal would still be discharged with the effluent. These dissolved substances exercise considerable oxygen demand on the receiving waters in that they are subject to bacterial action which reduces them to simpler and more stable chemical compounds. Secondary sewage treatment accomplishes this reduction within the sewage treatment plant so that the effluent as discharged to the stream is more stable and exerts less oxygen demand upon the stream than does raw sewage or primary treatment plant effluents.

Outside of Denver, communities of Ft. Lupton, LaSalle, Evans, Ft. Morgan, Brush, and Sterling give primary treatment to sewage wastes discharged to the South Platte River. The largest of these communities is Sterling with a population equivalent of 5,200 discharging to the stream. Since waters of the stream are used for irrigation below these cities, additional treatment is necessary. Secondary treatment is given the sewage discharges from Littleton and Brighton on the main stem. However, neither provides settling following trickling filtration.

Tributary Streams

Cheyenne discharges raw sewage to Crow Creek where it is impounded in a lagoon. Effluent from the lagoon is used directly for irrigation of forage crops. Cheyenne should provide for suitable treatment of its sewage because of the low dilution afforded by Crow Creek. A treatment plant is currently under consideration but is being held up because of legal matters.*

On Bear Creek the Federal Correctional Institution and Ft. Logan both provide secondary treatment. The former does not provide secondary settling.

Sand Creek has several communities including a section of Denver discharging sewage to the Creek. Denver and Aurora provide primary treatment, while Buckley Field (U. S. Navy Reserve) and Fitzsimons General Hospital (Army) provide secondary treatment for their sewage. Because of the erratic flow in this creek, all plants except those now considered adequate should provide additional treatment for wastes discharged into their watercourse.

On Lodgepole Creek, sewage from Kimball and Sidney receives secondary treatment. Sand filters are provided for secondary treatment of the primary effluent at Chappell but they are not used. Additional treatment is needed as the flow in the stream is quite erratic and dilution factors are uncertain. It is understood that steps have been taken towards the correction of this situation.

Industrial Wastes

Main Stem

The industrial wastes problems along the main stream, except for the beet sugar industry, are largely grouped about Denver. Packing plants discharging wastes directly to the stream in and immediately below Denver should either install treatment facilities or make arrangements for the treatment of their liquid wastes in the Denver sewage treatment plant. This latter alternative could be achieved by constructing a common sewer and pumping facilities. Any plants within the city, not now served or whose wastes can be accepted, should be connected to the municipal sewer system. The construction of a relief sewer, now under way, to serve the lower industrial area, will facilitate such action. The total industrial waste load contributed by Denver is estimated to have a population equivalent of about 180,000. The major portion of this load is tributary to the Denver sewage treatment plants. Oil and grease from railroad roundhouses create a serious pollution problem in the Denver area. This pollution should be abated.

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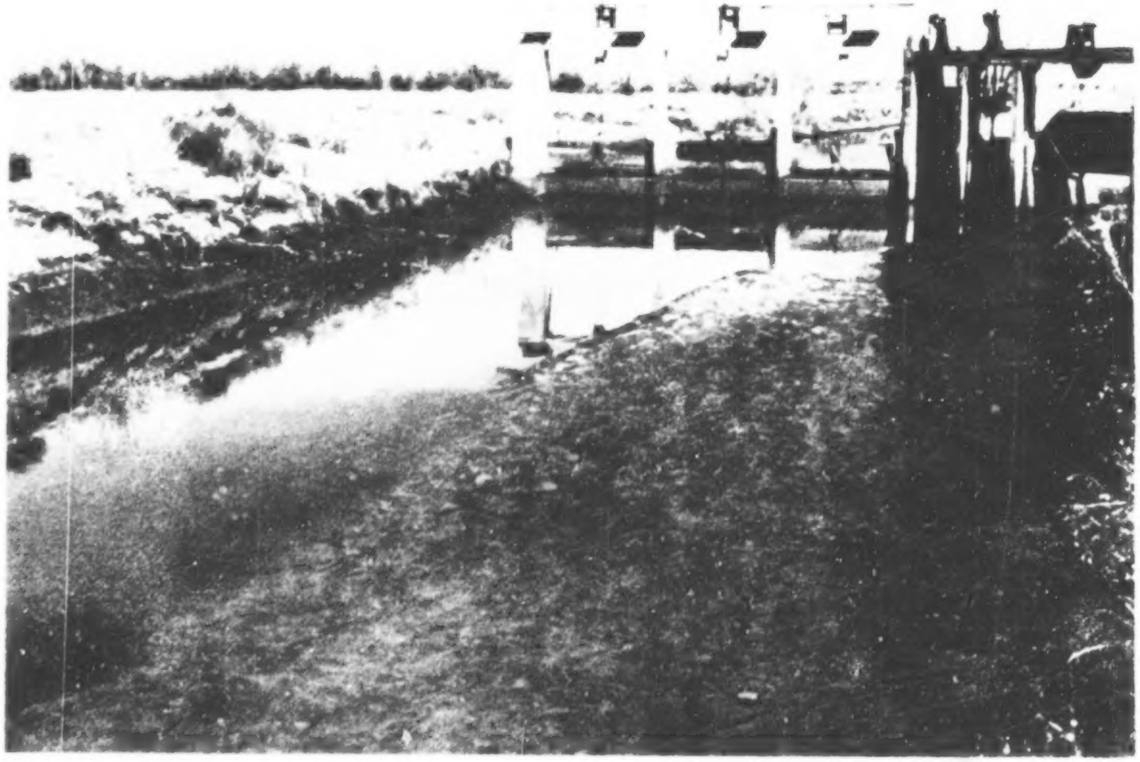
* Construction of a secondary treatment plant was started during 1951.



Sludge Banks in Burlington-O'Brian Canal near Barr Lake

The beet sugar industry, with five plants discharging wastes with a population equivalent in excess of 1,500,000 to the main stem, is the major industrial waste problem outside of the Denver area. The owners of five plants along the main river are taking steps to reduce water pollution by beet wastes and, over the next few years, should make progress in this direction. The waste disposal problem is being approached from the following angles:

1. Separation of wastes into component parts.
2. Re-use of certain waste waters by return to the process either with or without prior treatment.
3. By-product recovery from liquid wastes.
4. Cattle food production from spent pulp.

Methods are at hand which can be adapted for the material reduction of beet waste pollution, and these methods can be operated economically. The elimination of wastes from silo drainage, Steffens process and lime cake is entirely feasible, and the removal of these wastes alone will probably reduce the strength of the discharged wastes by 60% or more. Re-use of process waters will reduce remaining waste strengths by at at least 50% or more. In the first case the total stream load from these wastes would be reduced from a population equivalent of 1,538,000 to about 600,000. In the second case, the total population equivalent to the main stream would be reduced further to 300,000 or less. Further substantial reduction would still be required. (Refer to Appendix "F").

Minor Tributaries

Industrial waste pollution of the minor tributaries is relatively small. Oil refineries in the Denver area discharge to Sand Creek and the Burlington-O'Brian Canal. An oil refinery near Cheyenne discharges to Crow Creek. The total population equivalent of these refineries is estimated at about 14,000. Small dairies, and slaughterhouses, comprise most of the industries discharging to the tributaries in the vicinity of the larger towns. A paper mill having an estimated population equivalent of 7,800 discharges wastes to the Burlington-O'Brian Canal. Pollution from these sources should be abated. (See Table SP-7; Page 148).

Irrigation Usage

The major use of water along the main stream is for irrigation purposes. The appropriation of the stream flows for irrigation presents problems not usually found in water pollution investigations in more humid regions. These problems are the result of diversions of stream flows from the main channels for irrigation concurrently with the use of the stream for the disposal of sewage and industrial wastes. The diversion of sewage-polluted waters immediately below communities for irrigation use occurs at Denver, Ft. Lupton, Platteville, Sterling, Ovid, and Julesburg, on the South Platte; below Cheyenne on Crow Creek; and below Kimball and Lodgepole on Lodgepole Creek.

Stream flows are diverted on the east (right) bank of the South Platte immediately below Denver by the Burlington-O'Brian Canal and by the Gardner's Ditch on the west bank about one-half mile downstream from the outfall. The diversion weir for the Burlington-O'Brian Canal forces the entire stream flows into the inlet structure of the canal during low flows. Stream flow in excess of diversion requirements are returned to the river through a waste-way below the weir. Results of analyses of samples taken along the canal to the storage reservoir at Barr Lake located about 14 miles northeast of Denver indicate a highly polluted stream. Extensive sludge banks are present in the canal and in the upper part of the reservoir near the inlet to Barr Lake. During times of higher dilution in the summer months the condition along the canal show improvement over those found in the winter months when stream flows are at their minimum. Samples taken during the irrigation season from the outlets from Barr Lake show the effects of storage in improving the quality of the water stored in the reservoir.

Samples from the intake to the Gardner's Ditch during the irrigation season were indicative of polluted water. The same general indications were observed at the intakes to the Fulton and Brantner Ditches about 5 and 7 miles downstream from the Denver outfall, respectively. A summary of the laboratory results at ditches sampled below Denver during the irrigation season is presented in Table SP-12.

Table SP-12

Summary of Laboratory Results at Irrigation Diversions Below Denver for Irrigation Season 1949 (May - September)

Station	No. Samples	Value	Dissolved Oxygen		BOD	Coliform Bacteria per 100 ml (MPN)
			ppm.	% Sat.	ppm.	
Burlington-O'Brian Intake SP 298.8	26	Avg.	6.1	76	21.	59,000*
		Max.	8.	101	100	11,000,000
		Min.	1.9	26	0.8	7,500
Gardner's Ditch Intake SP 298.2	13	Avg.	5.9	75	18	190,000*
		Max.	7.7	92	45	2,400,000
		Min.	4.3	58	4.4	2,300
Fulton Ditch Intake SP 294.2	5	Avg.	4.4	53	43	93,000*
		Max.	6.2	74	77	2,100,000
		Min.	3.1	39	13	15,000
Brantner Ditch Intake SP 292	10	Avg.	5.3	66	9.6	310,000*
		Max.	7.3	92	22	930,000
		Min.	3.2	30	2.6	7,500
Barr Lake - West Outlet (Speer Canal)	29	Avg.	7.7	102	4.	1,215*
		Max.	9.2	130	> 7.8	24,000
		Min.	5.	67	1.6	230
Barr Lake - East Outlet (Neres Canal)	31	Avg.	7.5	99	5.6	4.300*
		Max.	11.9	162	16.	1,110,000
		Min.	4.6	59	2.1	430
Ft. Lupton gage SP 272.2	46	Avg.	5.7	72	10.	230,000*
		Max.	7.0	90	36	4,600,000
		Min.	4.5	56	2.5	15,000

* Median coliform value recorded and not average

The picture in the river below the Burlington-O'Brian Canal intake is complicated by the discharge of wastes from fix packing plants along the river. Only one of these plants gives any treatment to the wastes before discharge. An estimate of population equivalents of the wastes based upon kill and upon laboratory determinations is about 11,000. Gardner's Ditch intake is immediately above the two lowermost plants.

A special study was made to determine some of the health hazards of using polluted waters for irrigation of small fruits and vegetables within the limits of available funds, time, and personnel. The results of the 1949 season's activities are presented in detail in Appendix "G".

A summary of the laboratory analyses made on samples from other irrigation canals along the main stem and minor tributaries during the 1949 irrigation season is given in Table SP-13.

Table SP-13

Summary of Laboratory Results at Irrigation Diversions
for Irrigation Season 1949 (May - September)
South Platte River and Minor Tributaries

Station	No. Samples	Value	Dissolved Oxygen		BOD	Coliform Bacteria per 100 ml (MPN)
			ppm.	% Sat.	ppm.	
South Platte River						
Union Canal Intake SP 247.7	37	Avg.	7.6	97	2.1	23,000*
		Max.	9.9	114	5.7	1,100,000
		Min.	6	77	1.2	2,300
Riverside Canal Intake SP 227.5	46	Avg.	7.6	96	2.9	23,000*
		Max.	10.5	140	16.	460,000
		Min.	1.9	23	0.8	360
Empire Canal Intake SP 226.8 (Operating only part of season)	8	Avg.	7.0	91	3.7	101,500*
		Max.	11.0	149	7.7	460,000
		Min.	4.8	58	1.7	910
Bijou Canal Intake SP 216.6	36	Avg.	8.4	109	2.2	4,300*
		Max.	11.9	162	12.0	930,000
		Min.	5.0	61	1.1	930
Lower Platte & Beaver Canal Intake SP 178.4 Below Ft. Morgan, Colorado	35	Avg.	7.5	96	2.6	24,000*
		Max.	8.9	106	13.0	240,000
		Min.	6.0	74	1.3	2,300
Cole Extension Canal SP 155.4 Above Sterling, Colorado	8	Avg.	10.2	130	3.7	1,215*
		Max.	13.3	179	6.8	4,600
		Min.	7.2	96	2.1	230

Table SP-13 (Cont'd)

Station	No. Samples	Value	Dissolved Oxygen		BOD ppm.	Coliform Bacteria per 100 ml (MPN)
			ppm.	% Sat.		
So. Platte R.(Cont.)						
Peterson Canal Intake SP 103.6 Below Sedgwick	9	Avg.	7.5	100	3.3	930*
		Max.	8.4	117	4.7	24,000
		Min.	6.5	80	1.7	430
Western Canal Intake SP 84.5 Below Julesburg, Colorado	9	Avg.	8.3	112	2.5	43,000*
		Max.	10.8	149	3.1	110,000
		Min.	7.0	96	1.7	15,000
Hollingsworth Canal Intake SP 58.0 Above Ogallala, Neb.	7	Avg.	8.5	110	4.6	33,000*
		Max.	10.2	122	7.3	110,000
		Min.	7.3	101	2.9	2,100
Lodgepole Creek						
Oliver Reservoir Inlet Lod 112.8 Below Bushnell, Nebraska	13	Avg.	8.1	94	4.	1,500*
		Max.	8.7	103	11.	24,000
		Min.	6.8	73	1.8	36
Oliver Reservoir Outlet Lod 111.2	10	Avg.	5.7	67	3.8	930*
		Max.	9.2	104	5.1	24,000
		Min.	2.2	30	1.5	93
Bennett Reservoir Inlet Lod 101. Below Kimball, Nebraska	11	Avg.	7.3	90	3.6	43,000*
		Max.	9.2	110	7.5	110,000
		Min.	2.0	24	1.9	39
Bennett Reservoir Outlet Lod 100.3	6	Avg.	8.4	110	6.3	106*
		Max.	9.2	120	9.6	460
		Min.	6.3	84	3.4	43
Crow Creek						
Below Sewage Outfall, Cheyenne, Wyo. Cr 76.0	7	Avg.	0.4	4	55.	4,300,000*
		Max.	1.8	20	78.	11,000,000
		Min.	0	0	36.	430,000
Below Sewage Lagoons, Cheyenne, Wyo. Cr 72.5	9	Avg.	4.6	60	10.	24,000*
		Max.	6.8	84	20.	460,000
		Min.	2.0	36	6.1	4,300

* Median coliform count recorded, not average.

These results show that where canals are located so as to receive no direct pollution from waste discharges, the water quality is fairly good. Examples of such diversions are found at the Cole Extension and Peterson Canals in the stream stretch between Sterling and Ovid. Further, the possible benefits of storage in reservoirs are indicated in the results obtained at the outlets to the Oliver and Bennett Reservoirs on Lodgepole Creek and at the outlet of the lagoon or reservoir below Cheyenne on Crow Creek. The Oliver Reservoir receives pollution from Bushnell, Nebraska, while the Bennett Reservoir receives the treated wastes from Kimball, Nebraska. The lagoon on Crow Creek receives the untreated sewage from Cheyenne, Wyoming.

Probable Effects of Project Operations

The potential Blue-South Platte Project (Exhibit II) will increase the water resources of the South Platte River by an estimated 400,000 acre-feet annually, much of which will apply to the area adjacent to Denver. The Colorado-Big Thompson Project (Exhibit I), now under construction, will serve to increase the water resources of the St. Vrain, Thompson, and Cache la Poudre Rivers. Effects of this project will doubtless be felt in the main stem of the South Platte River below Platteville. The Bureau of Reclamation has made an analysis of the situation with regard to the estimated project effects on the stream flows of the South Platte River (See Appendix "H"). Their summary of this analysis, in part, is as follows:

"The flows of the streams in the project area will be increased to some extent by project operation. The degree of this increase will depend on several factors. In the winter months, November through May, the increase will depend on the amount of return flow from project water that comes back to the stream above the point in question and the amount of this return flow that can be rediverted by existing reservoir systems above this point. During the irrigation season, June through October, the increases will depend upon the following factors: The quantity of project water delivered to the stream, the quantity of project water diverted above the point in question, the amount of return flow from project water above the point, and the amount of this return flow that can be rediverted above this point by existing systems.

"The flow of the South Platte River at Denver would ordinarily be decreased during the early summer months under project development (Blue-South Platte). Since increased return flows would assure filling of downstream storage during the winter months and supply a large part of the summer demands, it would be possible to withhold water at Two Forks (reservoir) during the early summer. The estimated minimum future flows at the Denver gage (SP-302.3) are shown on following page.

"Future Minimum Flows of South Platte River at Denver Gage
(Second-Feet)

January	108	(33.4)*	July	171	(106)*
February	102	(38.5)*	August	128	(108)*
March	77	(54)*	September	221	(74.6)*
April	69	(58)*	October	186	(59.3)*
May	55	(68)*	November	123	(32)*
June	50	(101)*	December	91	(55.1)*

* (Lowest flow of record during month - for comparison)

"Minimum flows below the Burlington Ditch headgate would not be increased appreciably by project operation.

"It is anticipated that the flow at the Ft. Lupton gage (Station SP 272.2) would not be affected materially. The estimated minimum flows after project development at this point are tabulated below:

"Future Minimum Flows of South Platte River at Ft. Lupton
(Second-Feet)

January	66	(57)*	July	43	(35)*
February	77	(50)*	August	37	(34)*
March	52	(39)*	September	30	(21)*
April	36	(26)*	October	10	(10)*
May	68	(55)*	November	20	(20)*
June	37	(37)*	December	75	(56)*

* (Lowest flow of record during month - for comparison)

"The flow of the South Platte River at the Kersey gaging station (Sta. SP 231.9) will be affected by both the Colorado-Big Thompson and Blue-South Platte Projects. The estimated minimum flows are shown below:

"Future Minimum Flows of the South Platte River at Kersey Gage
(Second-Fset)

January	184	(158)*	July	106	(42)*
February	196	(152)*	August	117	(65)*
March	112	(80)*	September	104	(62)*
April	60	(35)*	October	82	(68)*
May	118	(40)*	November	90	(70)*
June	115	(58)*	December	129	(91)*

* (Lowest flow of record during month - for comparison)

"With construction of the Narrows Reservoir (about Station SP-190), it is anticipated that the minimum flows will be as shown below:

"Anticipated
Minimum Flows of South Platte River
Below Narrows Reservoir (second-feet)

January	34	(36)*	(200)**	July	153	(9)	(56)
February	35	(29)	(192)	August	190	(83)	(65)
March	34	(35)	(157)	September	181	(83)	(48)
April	47	(47)	(90)	October	37	(62)	(64)
May	228	(77)	(58)	November	30	(49)	(76)
June	654	(95)	(34)	December	33	(36)	(152)

* Recorded low flow during month at Sublette gage above Narrows Reservoir.

** Recorded low flow during month at Ft. Morgan gage below Narrows Reservoir."

This analysis indicates that storage above Denver by the Blue-South Platte Project would level off the peak flood flows of the early summer and increase low flows during the late fall and winter by project releases to supply the supplemental irrigation requirements. The flows at the Denver gage during the winter months will be larger because of increased return flows from project deliveries.

The general increase in minimum flows during the winter months, as shown by the Bureau of Reclamation analysis, would serve to improve to some extent stream conditions below the city in that the anticipated minima during January and February would be approximately three times the recorded minima at this point. In May and June, however, it is anticipated that the minimum flows will be less than those now existing at this point. This would result from the storage of normal spring runoff which occurs during these months.

The operation of the Blue-South Platte and Colorado-Big Thompson Projects would almost double the minimum flow of the South Platte River below the mouth of the Poudre at Kersey during the early spring and summer months. Minimum flows from here to Narrows during the remainder of the year would be increased to some extent. Operation of the proposed Narrows Reservoir as currently contemplated would greatly increase the summer minimum flows below the reservoir, but would reduce the flow between Narrows Reservoir and the North Sterling Canal above Balzac during the winter months. The effect of increased irrigation supplies resulting from the Blue-South Platte, Colorado-Big Thompson, and Narrows Projects would be to stabilize flows between Balzac and Julesburg and generally increase minimum flows.

Return flows from irrigation would tend to increase minimum stream flows in the lower South Platte River, but there are no reliable data from which estimates can be made at this time. Whether or not these return flows will be sufficient to materially alter present hydrologic conditions in the river is a matter of conjecture. It is anticipated that much of the increased return flows will be rediverted to irrigation storage during the winter months. In any event, it appears that sufficient dilution water cannot be obtained to bring about any appreciable reduction in pollution abatement needs.

Lodgepole Creek and Crow Creek will not be directly affected by either the Colorado-Big Thompson or the Blue-South Platte Projects, and studies of these streams are now being made by the Bureau of Reclamation in connection with the basin report but any proposals for development are as yet unknown.

Need for Water Conservation Measures

As previously indicated, Denver is a major source of pollution and it is possible under present conditions for the effluent from the Denver sewage treatment plant to constitute as much as 85% of the available stream flow below the city, using the daily minimum stream discharge of record at the Denver gage. Based upon monthly mean stream flow values (as previously indicated), Denver sewage effluent may contribute as much as 70% of the stream discharge below the city at times of low stream flow (see Table SP-10). In order to provide for increased flow in the South Platte River below the mouth of Clear Creek for the purpose of diluting their sewage treatment plant effluent and in order to compensate an exchange of upstream for downstream water rights, the City of Denver constructed the Jones Pass Diversion Tunnel. This project diverted water from the Williams Fork Creek to the head of Clear Creek. This diversion is now being utilized by the Denver Water Board to provide water to satisfy obligations to downstream water users in exchange for South Platte River water diverted by the city above Denver for water supply purposes. While some additional water is provided in the South Platte River below Clear Creek, this dilution water does not materially alter stream conditions between the Denver outfall and the confluence of Clear Creek with the South Platte River. Two important diversions, the Burlington-O'Brian Canal and Gardiner's Ditch, are made from this reach of the main river for irrigation purposes, which diversions are upstream from Clear Creek and are not therefore affected by Jones Pass Diversion water.

During the course of this survey, the dissolved oxygen in the stream above the Denver sewage treatment plant ranged as low as 4.5 ppm, although the summer and winter averages were 6.9 ppm and 8.9 ppm, respectively. At the Burlington-O'Brian Canal intake immediately below the Denver sewage treatment plant, the values fell to as low as 1.9 ppm. This indicates that the stream is at times not capable of maintaining a reasonable dissolved oxygen level under present conditions. Oxygen depletion is especially apparent along the O'Brian Canal where the dissolved oxygen often drops to zero and coliform MPN values are excessive. This canal has the characteristics of a stream receiving gross pollution. These characteristics are consistent with those noted in other areas where serious degradation occurs in the receiving stream as a result of insufficient dilution water unless a fairly high degree of sewage treatment is provided.

A higher degree of sewage treatment is needed at Denver. This was recognized by the City of Denver and its consultants and advisors at the time the present sewage treatment plant was constructed, as it was in-tended that the present plant provide secondary treatment. Growth of the city since the present plant was constructed has of course increased the pollution load from the city so that the need for a high degree of treatment is obviously greater now than at the time the present plant was constructed. Stream conditions below this city are now unsatisfactory and will become worse as the city grows unless more efficient sewage treatment is provided. The completion of the contemplated transmontane diversions and storage reservoirs will not result in the availability of sufficient dilution water to reduce the need for further treatment. Appropriation of stream flows greatly exceeds the available water supply, and any additional water which might result from transmontane diversions and increased storage is already appropriated to satisfy obligations to water users.

In common with other arid and semiarid regions, water has an unusually high value in this basin. Increasing water needs and the limited water supply have led to vast undertakings to augment the water resources of the basin. These undertakings have been directed towards the importation of water into the South Platte River Basin from the western slope of the Continental Divide. One of the keystones of the regional economy is agriculture. In this region a well-diversified agriculture is based upon the availability of water for irrigation purposes. The lack of sufficient water suitable for agricultural purposes could lead to great hardship and even to the abandonment of highly productive agricultural land. Therefore, the use of water in the basin should be governed to a considerable extent by the amount and the quality of water required for irrigation purposes.

Neglecting entirely the health aspects of the water problem and basing the discussion solely upon consideration of agricultural economy, it would appear that, after domestic water needs have been satisfied, the established economy of the region would require that the need for water for agricultural purposes must be met. That this water should be of a quality suitable for irrigation and other agricultural needs is obvious. The responsibility for maintenance of suitable water quality rests with the communities and the industries in the basin. The elimination of water pollution or the furnishing of additional waste treatment facilities over and above those now provided would afford economic insurance through the continued maintenance of suitable irrigation water quality. Neglect to take this step could affect the agricultural economy either because of the loss in production or because of reduction in market value of inferior crops. A case in point would be a serious loss of crop value which could result from a public boycott of irrigated crops because of a recognized health hazard associated with the use of contaminated water for irrigation purposes. This situation has a special significance in the area immediately north of Denver in that a large acreage in this region is devoted entirely to cultivation of truck crops. A considerable acreage adjacent to the mouth of Clear Creek and extending northward to the vicinity of Ft. Lupton uses available water from the South Platte River and from Clear Creek for irrigation purposes. There is no surface water available in this region which does not contain a relatively large proportion of the waste discharges from the various communities and industries located therein. Since the crops produced in this area are in excess of local consumption, the problem assumes more than local importance because the excess production is shipped to other population centers, some of which are in other states. High monetary returns per acre from production of truck crops make the expansion of this agricultural pursuit attractive where land values are high and where ready markets for the produce are available. Further, the increased cost of irrigation water because of higher construction and maintenance costs is an incentive for the farmer to increase his returns per acre. While, as stated previously, there are no reliable criteria at the present time which are applicable as yardsticks with which to measure the degree of these hazards, an outbreak of disease associated in any manner with produce irrigated with water containing appreciable amounts of sewage would seriously affect this agricultural industry and would result in much unfavorable publicity and serious damage to the industry. It is, therefore, incumbent upon the communities and industries to conserve water resources through the provision of adequate pollution abatement facilities.

In areas of limited water resources such as the South Platte River Basin, the used water supplies of communities and industries are needed to supplement total water resources. Since this is the case, sewage and waste treatment practices become means of water conservation and, as such, make a definite contribution to the assets of the region. This phase of sewage and waste treatment cannot be overlooked in areas such as this basin. The actual cost of sewage and industrial waste treatment under such conditions can be measured as the difference between the actual treatment cost and the value of the reclaimed water for other uses. The reclaimed waste waters will supplement the stream flow, rather than require additional stream flow for their dilution. This does not preclude the need for some dilution water, because no sewage treatment process is 100 per cent efficient and, therefore, some dilution is necessary.

CACHE LA POUDRE RIVER SUBBASIN

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CACHE LA POUDRE RIVER SUBBASIN

SYLLABUS

The Cache la Poudre River arises along the Continental Divide and flows for nearly 120 miles to its junction with the South Platte below Greeley, Colorado. The drainage area covers about 1,840 square miles. The stream above Ft. Collins, Colorado, is utilized extensively for recreational purposes and as the source of public water supplies for Ft. Collins and Greeley, Colorado.

Sewage and industrial wastes with a total population equivalent of about 1,288,000 are discharged into the stream. Of this amount, 1,240,000 population equivalent is contributed during a short period in the late fall by factories processing sugar beets. The bulk of the domestic sewage pollution is contributed by the cities of Ft. Collins and Greeley, Colorado. Ft. Collins provides secondary treatment. Eaton and Greeley provide primary treatment for their sewage. Windsor provides secondary treatment but no final settling.

The major subbasin water usage is for irrigation. This greatly affects the stream flows below the diversions. Pollution seriously affects the quality of waters diverted below Greeley.

The Colorado-Big Thompson Project will supply additional water to the Poudre at the delivery point above the Poudre Valley Canal. It is anticipated that this water will provide flows at this point of 600 or more c.f.s. during June, July and August, and somewhat less during September and October. These flows will be materially decreased by diversions so that the stream flows below Ft. Collins will be considerably less. No additional water will be provided by the project during the period from November through May.

CONCLUSIONS

1. Surface water supplies serve three communities in the subbasin from two systems. Total population served is approximately 36,000. Treatment is provided and combined treatment plant capacity is 18.0 MGD.

2. One public water supply is obtained from a shallow well. The supply is untreated and consumption is estimated at 0.25 MGD serving a population of 1,700.

3. Four sewered communities in the basin are served by sewage treatment plants. Population served is about 36,300. Two plants serving 17,000 population provide for secondary treatment. Two other communities provide primary treatment for about 19,300 population.

4. Industrial waste population equivalent loading is estimated at 1,252,000, of which amount 1,240,000 is contributed by 4 sugar beet processing plants during the months of October, November and December.

5. Industrial wastes have a profound effect upon the stream oxygen balance in the fall months. Median coliform counts in the plains area show the effects of sewage discharges. Water quality in the stream above Ft. Collins is good.

6. Increase in stream flows is anticipated during the summer months when operations of the Colorado-Big Thompson Project are begun a few years hence. The extent of winter flow increases is problematical. Increased flows expected below larger communities will not decrease the sewage treatment requirements of these communities or decrease the need for industrial waste pollution abatement.

RECOMMENDATIONS

1. Water quality should be protected, to the extent required for reasonable water use, by provision, as necessary, of sewage treatment including adequate chlorination.

2. More adequate sewage treatment for those communities now providing primary treatment, namely Greeley and Eaton. Installation of secondary settling at the Windsor plant.

3. Adequate waste treatment or reduction or both should be provided for industrial wastes as necessary to protect downstream water quality and use.

4. Adoption of measures to afford maximum protection to headwaters areas used for water supply sources and for recreation from undue contamination from improper wastes disposal practices.

DESCRIPTION

The Cache la Poudre River arises along the eastern slope of the Continental Divide in Larimer County, Colorado, and along the Colorado-Wyoming border. The main stem of the Cache la Poudre arises on the Divide at Fall River Pass in Rocky Mountain National Park and flows north and then eastward to its junction with the North Fork and hence in a general southeasterly direction to its junction with the South Platte River east of Greeley, Colorado. The total length of the main stem is approximately 120 miles, and the drainage area embraces about 1,840 square miles. Stream slopes are precipitous in the headwaters, and velocities are swift. Above the canyon outlet, stream slopes are in excess of 25 feet per mile and, below Ft. Collins, slopes are in excess of 9-10 feet per mile. Stream beds are generally rocky, and even in the plains area below Ft. Collins the stream is narrow and flows are relatively swift. Elevations along the stream vary from above 10,000 feet to 4,600 feet at its mouth below Greeley.

Temperatures, rainfall, and humidity ranges are the same as for the South Platte Basin generally.

PRESENTATION OF DATA

Public Water Supplies

Public water supplies for Ft. Collins and for Greeley are derived from the headwaters of the Cache la Poudre River and from the North Fork. The Ft. Collins supply is taken from the Poudre above its junction with the North Fork and the Greeley supply is taken below the junction with the North Fork at the intake of the Poudre Valley Canal. The Greeley supply has an impoundment on the North Fork just above its junction with the Cache la Poudre (The Milton Seamen Reservoir). Both communities provide for treatment of the raw water before use. The salient features of these supplies are as follows:

Table C1P-1 - Public Water Supplies from Surface Sources

Community	Estimated Population	Source	Plant Capacity	Type of Treatment
Greeley	18,000	Cache la Poudre North Fork	9.0 MGD	Rapid Sand Filters; Slow Sand Filters; Disinfection
Ft. Collins	18,000	Cache la Poudre	9.0 MGD	Rapid Sand Filtration; Disinfection

The town of Windsor obtains its water supply from the City of Greeley. No other communities in the Cache la Poudre Basin have public water supplies except Eaton (est. pop. 1,700), which has a shallow well. The water is untreated and the daily consumption is estimated at about 0.25 MGD.

Sources of Pollution

Table C1P-2 on the following page summarizes the magnitude and location of significant sources of pollution discharged to the Cache la Poudre River. Industrial wastes from seasonal operations have been separated from other wastes so as to give a clearer picture of the over-all pollution problem for the greater part of the year.

The maximum estimated population equivalent of the untreated wastes of the communities and industries along the Poudre is estimated as 1,288,000. Of this number, the seasonal industrial waste load accounts for 1,248,000, of which 1,240,000 represents the beet sugar industry and the remainder is contributed by canneries. The average population equivalent, excluding these seasonal industries, is estimated as 40,000, which is reduced to treatment to 20,000 at the time of discharge to the streams. The bulk of the nonindustrial pollution is contributed by the sewered populations of Ft. Collins and Greeley.

Table ClP-2 - Summary of Wastes Discharged to Cache la Poudre River

Source	Stream (1)	River Mileage Above Mouth	Sewered Pop.	Type of Treatment (2)	Estimated Population Equivalent BOD	
					Untreated	Discharged
Ind. Waste	ClP	ClP 38.0	-	None	60	60[a]
Ft. Collins	ClP	ClP 37.8	15,000	S	15,500	2,300
Ind. Waste	ClP	ClP 37.3	-	None	3,360	3,360
Ind. Waste	ClP	ClP 36.0	-	None	710,000	710,000[b]
Windsor	ClP	ClP 21.4	2,000	S	2,000	800[c]
Ind. Waste	ClP	ClP 21.2	-	None	210,000	210,000[b]
Eaton	Unnamed Creek	7.0	1,300	P	1,300	910
Ind. Waste	Unnamed Creek	7.0	-	None	140,000	140,000[b]
Ind. Waste	ClP	ClP 6.0	-	None	410	410
Ind. Waste	ClP	ClP 4.5	-	None	2,300	2,300[e]
Greeley	ClP	ClP 4.4	18,000	P	19,400	13,000[d]
Ind. Waste	ClP	ClP 4.4	-	None	3,400	3,400[f]
Ind. Waste	ClP	ClP 4.1	-	None	180,000	180,000[b]
Ind. Waste	ClP	ClP 3.5	-	None	60	60

(1) ClP - Cache la Poudre
(2) P - Primary Treatment;
S - Secondary Treatment.
a - Intermittent Discharge
b - Seasonal October-December.
c - No secondary settling provided.
d - About 1/3 of sewage by-passed plant pending installation of pumps.
e - Seasonal October-November.
f - By-passed treatment plant 1949; Seasonal August-October.

The sewage from Ft. Collins and Windsor receives secondary treatment but Windsor provides no secondary settling. Greeley provides primary treatment for its sewage and at the time of this survey was providing treatment for about two-thirds of the total sewage flow. Sewage from Eaton is treated in a septic tank. Sand filters provided for secondary treatment of the septic tank effluent are not used.

The major industrial waste loading on the stream is provided by the wastes from 4 beet sugar factories located near Ft. Collins, Windsor, Eaton, and Greeley. Canneries are located at Ft. Collins and at Greeley. The one at Ft. Collins packs cherries, and the Greeley plant handles vegetables. Two small slaughterhouses are located on the Poudre, one each at Ft. Collins and Greeley. There is also a large poultry packing plant and a small rendering plant at Greeley. A cheese factory at Ft. Collins contributes a fairly large nonseasonal industrial waste load which is probably as much as 50% in excess of that contributed by the effluent of the city sewage treatment plant. There are other small industries contributing a total of about 600 population equivalent to the stream.

Laboratory Results

Average results for summer and winter seasons, together with major sources of pollution, are shown in Figure C1P-1. The laboratory results covering determinations of dissolved oxygen, B.O.D., and median coliform counts are shown for the main stream only. These data are also shown graphically on Figures 6, 8, and 10 for the summer season (May to September), and on Figures 7, 9, and 11 for the winter season (October to April). The results presented in the above figures are averages for the periods designated and do not show the most critical conditions at any given station. For a more detailed picture at any given point, reference is made to the Summary of Individual Results appearing in Appendix "J," or to the Summary of Seasonal Results which appears in Table 34 in the General Section.

Dissolved Oxygen

The dissolved oxygen results are generally good throughout the stream length during the summer period from May to September, with the exception of sags below Ft. Collins, Windsor, and Greeley. Even in these cases, the average saturation level does not fall below 75%. The dissolved oxygen picture during the winter season from October to April is much less favorable because of the influence of industrial waste discharges on the dissolved oxygen in the stream. The influence of the tremendous loads resulting from the operation of the beet sugar industry during the period from October to December is manifest by the lower averages obtained for the winter season. Dissolved oxygen levels in the stream below Windsor during this period averaged only 3.8 ppm. This value gradually increased to about the saturation level at a point above Greeley in a stream stretch of about 10 miles. Saturation deficits below Ft. Collins and Greeley during the winter season were not as profound as that shown for Windsor. In the case of Ft. Collins, this may have been the result of the diversion of waste-laden waters to reservoirs at Timnath and Fossil Creek so that the full effects of the wastes were not manifest at stations below the points of diversion. In the case of Greeley, the waste-laden waters reach the main stream of the South Platte River before maximum dissolved oxygen deficits were obtained.

B.O.D. Results

B.O.D. results were higher during the winter season than during the summer. Here again, the high winter averages were the result of the wastes from sugar beet processing. Averages in excess of 300 ppm were recorded below Ft. Collins and Windsor, while the average below Greeley was slightly in excess of 40 ppm. The low BOD values obtained in the stream above Windsor (below Ft. Collins) were probably due to the fact that the waste-laden waters were diverted to Timnath and Fossil Creek Reservoirs. The samples taken above Windsor did not reflect the conditions which probably would have resulted had these waters been allowed to remain in the stream. The effectiveness of the sewage treatment plant installed at Ft. Collins is reflected in the relatively slight increase in B.O.D. below the city during the summer period. By the same token, the relatively high B.O.D. recorded below Greeley during the summer months reflected the partial treatment of the sewage from that community.

Coliform Results

Lower median coliform counts are recorded during the summer period, with the exception of the station immediately below Greeley. In general, counts at stations above Ft. Collins during this period had median values of less than 1,000 per 100 ml. The stream between Ft. Collins and Greeley showed a rise in coliform count reaching a maximum of 15,000 per 100 ml. below Windsor. The median coliform count immediately below Greeley reflects the inadequacy of sewage treatment at this point in reducing the bacterial numbers to relatively safe proportions. During the winter months from October to April, median coliform counts above Ft. Collins were below 1,000 per 100 ml. Sharp rises to values of near 1,000,000 per 100 ml. occur below Ft. Collins, Windsor, and Greeley. Here again, these counts are the result of the activities of the sugar beet industry during the winter period.

Chemical Results

Copper was investigated because of its effects on the B.O.D. determination when present in amounts in excess of 0.01 ppm. Maximum copper contents of about 0.20 were recorded above Ft. Collins. This figure fell to maxima of 0.07 below Greeley. Hardness values near the headwaters are quite low with maximum values of 25 ppm. in the vicinity of the Greeley water supply intake. These values, however, increase rapidly downstream until maximum hardness in excess of 1,000 ppm. is recorded in the vicinity of Greeley. Alkalinity values also show a marked increase from the headwaters to the mouth, but the values are generally not much in excess of 300 ppm. at Greeley. The increases in hardness and alkalinity are in all probability due to increased mineral content brought about by the leaching action of the return irrigation waters which remove chemicals from the soil.

Low-Flow Frequencies

Table C1P-3 summarizes a study of low mean monthly flow frequencies during the period of record for 2 gaging points on the Poudre River. The periods of record vary from 31 to 64 years. Low flows were computed for the summer period from May to September and for the winter period from October to April which corresponds roughly to the irrigation and non-irrigation seasons.

Low stream flows are important as they affect the amount of dilution available for wastes discharged to the stream. The available dilution, in turn, has a profound effect upon the degree of waste treatment required so as to prevent nuisance or to reduce bacterial concentrations in the stream in accordance with requirements of downstream water usage.

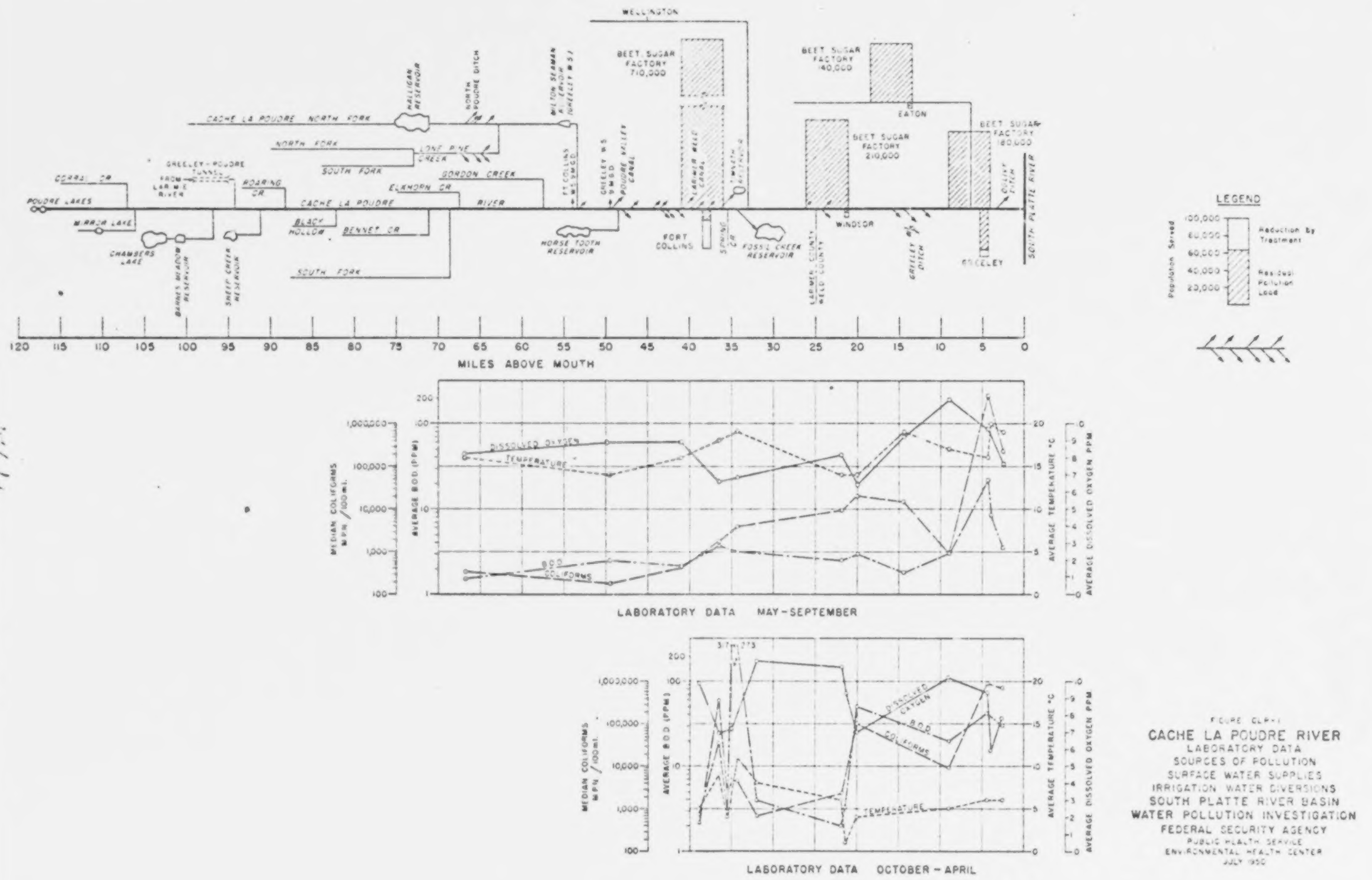

FIGURE CLP-1

CACHE LA POUDRE RIVER
LABORATORY DATA
SOURCES OF POLLUTION
SURFACE WATER SUPPLIES
IRRIGATION WATER DIVERSIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

MLP

Table C1P-3 **Frequency of Low Mean Monthly Discharges Cache la Poudre River**

Gaging Station Location on Cache la Poudre River	Miles Above Mouth	Drainage Area in Square Miles	Years of Record	Values in Cubic Feet per Second which the Mean Monthly Flow May Be Expected to Equal or to Be Less Than on the Average of Once in:								Low Mean Month of Record in Cubic Feet per Second	
				2 Years		3 Years		5 Years		10 Years			
				Summer (1)	Winter (2)	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Canyon Mouth near Ft. Collins	49.9	1,048	64	170	21	140	17	115	14	85	11	48	8.1
Greeley	2.5	1,840	31	14	24	13	18	11.5	11	10	5	5.4	6.6

(1) Summer - Irrigation Season, May 1 to September 30.
(2) Winter - Non-Irrigation Season, October 1 to April 30.

DISCUSSION

Waste Treatment Status and Needs

Municipal Sewage

No raw sewage is discharged directly to the Cache la Poudre River except that which was by-passing the Greeley sewage treatment plant during the course of this survey. Communities of Ft. Collins and Windsor provide secondary treatment for their sewage before discharge to the river. The Ft. Collins treatment plant is a modern high-rate filter installation and affords a B.O.D. reduction of approximately 85% as determined by efficiency tests run on this plant during the winter of 1949. No secondary settling is provided at the Windsor plant. The latter condition permits humus discharged from the filter to enter the stream with the plant effluent. This material often has a very high B.O.D. Windsor should provide a secondary settling tank plus chlorination.

Eaton provides a septic tank and sand filters for treatment of its sewage before discharge to an unnamed dry run about 7 miles above its confluence with the Poudre. The sand filters are not being used to provide secondary treatment for the septic tank effluent. Eaton should provide secondary treatment plus chlorination.

Greeley provides primary treatment for its sewage. At the time of the survey, only about two-thirds of the sewage flow was receiving treatment. This situation has been corrected by the installation of pumps to raise the remaining sewage to the plant elevation. Water quality in the Poudre below the treatment plant is unsatisfactory as shown by the laboratory data. With sewage flows somewhat in excess of 3 MGD, it is possible for the sewage to make up 50% of the recorded minimum stream flow at Greeley. Once in two years, the sewage flow could be expected to comprise 35% of the stream flow during the summer period. Further, diversion for irrigation is made about 0.3 mile below the plant outfall. The present plant was designed for use of chemical precipitation, but this feature is not used at present. The conclusion is that Greeley should revise its treatment plant to provide secondary treatment plus effective effluent chlorination.

Industrial Wastes

Beet Sugar Industry - The major industrial waste problem on the Cache la Poudre River is the seasonal discharge of beet sugar processing wastes to the stream from 4 factories which are located at Ft. Collins, Windsor, Eaton, and Greeley. The combined estimated population equivalent of these plants is 1,240,000. Individual plant loads vary from 710,000 at Ft. Collins to 140,000 at Eaton. The wastes from these plants receive little or no treatment before discharge to the streams. Although the stream is profoundly affected by the discharge of these wastes during the campaign, it appears to recover fairly promptly after the cessation of operations. (See Summary of Individual Results, Appendix "J")

Effects of these wastes on the stream are most noticeable below Windsor and Greeley. The Ft. Collins plant contributes the heaviest load, but the waste-laden waters are diverted to irrigation reservoirs at Timnath and Fossil Creek so that their full effects are not manifested in the stream below the points of diversion. In fact, there was no flow in the Poudre below the Fossil Creek intake during most of the 1949 campaign because of flow diversions.

The re-use of flume waters from the plant at Eaton, after settling to remove coarse suspended matter, is necessary because of shortage of fresh water for operating the flumes The wastes from this plant are discharged to the same watercourse which receives the effluent from the town septic tank. The re-use of the flume water greatly reduces the volumes of waste from this plant.

The management of the sugar beet plants in the basin is planning steps designed to reduce the waste load from its plants. The waste disposal problem is being approached from the following angles:

1. Separation of wastes into component parts.
2. Re-use of certain waste waters by return to the process either with or without prior treatment.
3. By-product recovery from liquid wastes.
4. Cattle food production from spent pulp and molasses.

Indications are that reduction of pollution can be accomplished economically and that removal of silo drainage, Steffens waste, and lime cake will eliminate at least 60% of the pollution load. Such action would reduce the present estimated population equivalent to about 496,000. If re-use of process waters were accomplished, the total population equivalent could be reduced by an estimated additional 20% to 248,000. However, this would still leave an objectionably high pollution load. Elimination of water pollution by beet wastes is the goal to be achieved.

Other Industries - Other industrial wastes loads are small in comparison to that of the sugar industry. A major pollution load results from a cheese factory below Ft. Collins. Pollution from this source should be corrected, either by treatment or by waste elimination or by a combination of these methods. Table C1P-4 on the following page summarizes the industrial wastes discharged to the streams.

Table C1P-4 Summary of Industrial Wastes

Type of Industry	Number of Plants	Estimated Population Equivalent (BOD)
Cheese Plant	1	3,360[a]
Beet Sugar	4	1,240,000[b]
Dairy	1	160
Slaughterhouse	2	120
Rendering Plant	1	410
Vegetable Seed	1	2,300[c]
Potato Chips	1	250
Poultry Packing	2	1,390
Cannery	2	4,000[d]

a - Cheddar and cottage cheese.
b - Seasonal, October-December.
c - Seasonal, September-October.
d - Seasonal, July-October.

Irrigation Usage

The major water usage is for irrigation purposes. The appropriation of stream flow brings about problems not usually found in more humid areas. The degree of self-purification accomplished in the stream is difficult, if not impossible to determine. Laboratory results from any given station do not necessarily reflect improvement from stations above because there may be one or more complete changes of water represented in the series. During low-flow conditions, diversions may appropriate the entire stream flow at points so that downstream flows are the result of drainage and seepage return to the stream. That such return may be considerable is reflected in the fact that such flows in the basin may amount to as much as 10 second-feet per mile under present conditions. Irrigation with water contaminated by sewage is open to question because of the health hazards which are involved. Diversion of sewage-laden waters occurs below Ft. Collins, Windsor and Greeley. Laboratory results showing the sanitary quality of water sampled at various canal intakes on the Poudre during the 1949 irrigation season are presented in Table C1P-5 on the next page.

It is seen from the table that those canals located so as not to receive extensive pollution, such as the North Poudre, Poudre Valley, and Larimer and Weld Canals, do not show waters of poor sanitary quality. Samples from ditches below Ft. Collins show questionable sanitary quality and those from below Greeley show heavy pollution - further showing the need for Greeley to abate pollution.

Table ClP-5 - **Laboratory Results at Irrigation Diversion**, 1949

Station	Number Samples	Value	Dissolved Oxygen ppm	Dissolved Oxygen % Sat.	BOD	Coliforms
North Poudre Canal ClP-NF 14	10	Av.	8.2	100	1.5	335*
		Max.	9.0	107	2.5	2,400
		Min.	7.8	93	0.8	43
Poudre Valley Canal ClP 49.8	6	Av.	8.9	103	2.4	190*
		Max.	9.4	107	3.3	4,600
		Min.	8.6	99	1.5	14
Larimer and Weld ClP 41	9	Av.	8.9	106	2.2	430*
		Max.	9.4	116	2.9	2,400
		Min.	8.4	98	1.6	43
Timnath Reservoir Inlet ClP 36.5	6	Av.	6.6	82	3.7	1,800*
		Max.	15.2	179	6.1	9,300
		Min.	3.5	43	2.1	910
Timnath Reservoir Outlet	9	Av.	7.2	93	4.4	930*
		Max.	9.6	128	7.8	4,300
		Min.	1.8	23	1.7	430
Fossil Creek Intake ClP 34.3	9	Av.	8.4	108	3.4	3,900*
		Max.	12.1	172	6.8	24,000
		Min.	5.1	67	1.8	2,300
Fossil Creek Outlet	8	Av.	4.9	66	4.6	590*
		Max.	7.2	99	7.1	930
		Min.	1.5	18	2.7	91
Greeley Ditch #3 ClP 14.4	37	Av.	9.2	117	1.8	15,000*
		Max.	11.7	150	3.7	110,000
		Min.	7.1	84	1.0	1,500
Ogilvy Ditch Intake	37	Av.	5.9	76	8.7	2,300,000*
		Max.	7.7	101	20.0	9,300,000
		Min.	3.8	50	2.0	43,000

* Median value and not average.

Recreational Usage

The upper portion of the Cache la Poudre and its tributaries above the canyon mouth are extensively utilized for recreational purposes. The streams are popular fishing spots and are much used for that purpose. The Colorado Game and Fish Department stocks the upper Poudre each year. Ft. Collins maintains a park near their waterworks intake. The North Fork is fenced off at the Seamen Reservoir and use above that point is more or less restricted by the Greeley Water Department. It is believed that the Poudre Canyons can be maintained for recreational use, especially fishing, as there is little habitation on the upper watershed. Proper sanitation facilities should be provided for those who visit the area so as to prevent undue contamination of the waters which also serve as sources of public water supplies. Sewage disposal practice at camps or other recreational establishments should be rigidly controlled. Proper chlorination of any sewage effluents reaching the streams should be a requirement.

Probable Effects of Project Operations

The Colorado-Big Thompson Project will deliver project water to the Cache la Poudre River. The delivery point will be approximately 8 miles upstream from Ft. Collins above the Poudre Valley Canal diversion but below the North Poudre Canal diversion point. The anticipated average increase in stream flows at the delivery point, as based upon the 28-year stream flow averages (1920-1947), is presented in the table below:

Table C1P-6 Anticipated Stream Flow Increase Resulting from Colorado-Big Thompson Project Operation

Month	Cache la Poudre at Delivery Point		Recorded* Mean Low Monthly Flow c.f.s.
	acre-feet increase	c.f.s. increase	
June	10,822	180	442
July	25,889	431	201
August	31,875	531	116
September	23,500	392	48
October	12,184	203	49

* Ft. Collins gage, at canyon mouth.

The values shown in the above table represent the average increase from project operation, as nearly as can be determined, at the immediate point of delivery. There will be no increase in flows at the point from November to May since all return flows will appear below the delivery point. The actual increase in stream flows at points below the delivery point will depend upon several factors. In the off-irrigation season, the increase will depend on the amount of return flow from project water that comes back to the stream and the amount of this return flow that can be rediverted by existing reservoir systems above the point in question. During the irrigation season, the increases will depend upon the quantity of project water delivered to the stream; the quantity of water diverted upstream; the amount of upstream return flow; and the amount of upstream rediversion of the return flow.

Taking all of the above into consideration, the following estimate was made of the increase in stream flow in the Cache la Poudre River at Ft. Collins, Colorado, as a result of Project operation:

Table C1P-7

Estimated Increase in Flow at Ft. Collins, Colorado

Month	Increase c.f.s.	Month	Increase c.f.s.
January	2	July	84
February	2	August	108
March	2	September	82
April	2	October	45
May	3	November	3
June	38	December	2

The above flow increases would be of little value in correcting the pollution in the Poudre below Ft. Collins resulting from sugar beet processing in the late Fall. However, the increased summer flows will serve to dilute sewage effluent from the city treatment plant and from industrial waste discharges during the irrigation season. This benefit will not obviate the need for treatment during the period, especially for chlorination of the effluent to control bacterial numbers, nor will it obviate the need for treatment for the cheese plant wastes entering the stream below Ft. Collins.

ST. VRAIN CREEK SUBBASIN

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ST. VRAIN CREEK SUB-BASIN

SYLLABUS

The St. Vrain Creeks arise along the Continental Divide. The main stem is formed by the junction of the North and South Forks at Lyons, Colorado. The drainage area embraces about 1000 square miles, about half of which is the watershed of the Boulder Creeks.

Seven communities utilize surface water sources for their water supplies. The largest communities are Boulder and Longmont, having a combined population of nearly 28,000. The combined population of the remaining communities is about 7,000. All communities, except one, provide for treatment of the water supply before use.

Total population equivalent of the pollution load to basin streams is 748,000, of which number 718,000 are attributable to seasonal industrial wastes. The sewage from approximately 30,000 persons is dumped to the streams. Treatment is provided by the three sewered communities. Only one community provides for secondary treatment, but this plant does not afford final settling. The industrial waste loading is concentrated about the City of Longmont where a large cannery and a beet sugar factory are located.

Water quality in the mountainous headwaters areas is good. Below Boulder and Longmont the effects of pollution loads are manifest, especially in the fall below Longmont.

Main water usage is for irrigation especially on Boulder Creek. In general, the sanitary quality of the irrigation water above sources of pollution is satisfactory.

Project water from the Colorado-Big Thompson will be delivered to St. Vrain Creek at Lyons, Colorado. It is not anticipated that Boulder Creek will receive supplemental water from the Colorado-Big Thompson Project but this is not yet decided. The proposed Blue-South Platte Project will provide supplemental water to South Boulder Creek. It is estimated that increase in flows at Longmont resulting from operations of the Colorado-Big Thompson Project will be about 12 cfs in the summer months, and perhaps 8 cfs in the winter months as a result of return flows. Such flows will have little effect upon industrial wastes discharges in the fall and will not obviate the need for adequate sewage treatment.

CONCLUSIONS

1. Surface water supplies are used by all larger communities in this basin. There are 7 such supplies serving some 35,000 persons. Combined capacity of all supplies is 13.5 MGD. One small community provides no treatment for its supply; all other communities provide treatment.

2. All three sewered communities in the basin are served by treatment plants. One community provides secondary treatment but no secondary settling is afforded so that its efficiency is reduced thereby. The other two communities provide primary treatment only. Total population served by the three sewered communities is about 30,000.

3. Industrial waste loading is about 718,000 population equivalent centered about Longmont. The beet sugar factory accounts for 700,000 population equivalent loading, and canneries the remainder.

4. Industrial waste discharges have a profound effect upon the stream in the fall season below Longmont. Water quality in the headwaters streams is generally good.

5. Sewage discharges from Boulder are reflected in the high coliform contents found in the stream below that point.

6. Increased stream flows are anticipated in the St. Vrain from operations of the Colorado-Big Thompson Project a few years hence. The increase expected below Longmont will not have much effect upon the industrial waste load and will not reduce the need for sewage and industrial wastes pollution abatement in this area.

RECOMMENDATIONS

1. Water quality should be protected to the extent required for reasonable water use by provision, as necessary, of sewage treatment, including adequate chlorination.

2. Installation of a secondary settling tank at Longmont to improve over-all plant efficiency. Improved sewage treatment at Boulder.

3. Adequate waste treatment or reduction or both should be provided for industrial wastes as necessary to protect downstream water quality and use.

4. Adoption of measures to afford adequate protection to headwaters areas used as sources of public water supplies and for recreation.

5. Provision of improved water treatment facilities where required.

DESCRIPTION

The St. Vrain system of creeks arises in the steep mountainous area along the eastern slope of the Continental Divide at elevations in excess of 12,000 feet. The main stem is formed at the junction of North and South St. Vrain Creeks at Lyons, Colorado. The creek flows southeasterly to its junction with Boulder Creek east of Longmont, Colorado, and hence northeasterly to its junction with the South Platte River near Platteville, Colorado (SP-253.4). The drainage area covers approximately 1,000 square miles.

The main tributaries of the St. Vrain are the North St. Vrain, the Middle St. Vrain, the South St. Vrain, Lefthand Creek, the Boulder Creek System, and Coal Creek. Boulder Creek is the most important tributary and embraces nearly half of the drainage area.

The major communities are Boulder, the site of the State University, and Longmont, an agricultural market center. The upper portions of the drainage area are utilized extensively in the summer months as a popular resort area. There are many cabins and resorts situated on or near the streams. The headwaters of Boulder Creek, especially the South Boulder Creek area, are historic for early day mining activities. South Boulder Creek is also utilized as the receiving stream for the transmontane diversion through the Moffat Tunnel from the Frazer River project of the Denver Water Supply.

Elevations vary from about 12,500 feet in the headwaters to about 4,700 feet at the mouth in a stream stretch of about 60 miles. Slopes are steep, ranging from several hundred feet per mile in the headwaters to about 18 feet per mile near the mouth. Stream beds are rocky and water velocities are swift. In the stretch below Longmont, the stream widens out and the stream bed changes from rocky to a sandy-gravel formation.

Temperatures, rainfall, and humidity vary little from those described in the general section of the report for the South Platte Basin.

PRESENTATION OF DATA

Public Water Supplies

Public water supplies serving an estimated 35,800 persons (1940 population 26,497) are obtained from surface sources. Table SV-1 lists the communities and their sources of supply.

The watershed utilized by Boulder for its supply is fenced and patrolled by the city. There are six reservoirs with a total impoundment of 3,500 acre-feet in the protected area. Chlorination is the only treatment given the water prior to use. The Nederland supply is taken directly from the creek and receives no treatment. The Colorado State Health Department recommends treatment of this water supply.

The supplies for Louisville, Lafayette, and Erie - all coal mining communities - are all derived from South Boulder Creek by way of irrigation canals to various reservoirs. All three communities provide for

Table SV-1 Public Water Supplies from Surface Sources

Community	Watershed	Source	Estimated Population Served 1949	Treatment	Capy. MGD
Nederland	Boulder Cr.	Boulder Cr.	400	None.	0.25
Boulder	Boulder Cr.	Boulder Cr.	20,000	Chlorination	6.
Louisville	Boulder Cr.	Marshall Lake	2,500	Rapid Sand Filtration; Chlorination	1.0
Lafayette	Boulder Cr.	So.Boulder Cr.	2,500	Rapid Sand Filtration; Chlorination	0.5
Erie	Boulder Cr.	Irrigation Ditch	1,200	Rapid Sand Filtration; Chlorination	0.5
Lyons	St.Vrain Cr.	No.St.Vrain	700	Pressure Filters	0.25
Longmont	St.Vrain Cr.	St.Vrain	8,500	Rapid Sand Filtration; Chlorination	5.0

treatment by the usual rapid sand filtration process followed by disinfection with chlorine.

Longmont and Lyons derive their supplies directly from the St. Vrain Creeks. The Lyons source is inadequate. Additional water may be procurable from the Colorado-Big Thompson project but the Lyons intake is above the point of delivery which is at the western city limits of Lyons. Treatment for the Lyons supply is considered inadequate by the Colorado State Department of Health.

The Longmont supply receives rapid sand filtration and disinfection with chlorine prior to use. It might be advantageous to consider combining the Longmont and Lyons supplies into a single public water supply serving both communities. This would be a feasible project especially if further consideration is given to the enlargement of the Longmont water treatment plant.

No other communities in this sub-basin have public water supplies.

Sources of Pollution

Table SV-2 summarizes the magnitude and location of significant sources of pollution discharged to the St. Vrain Creek system. Industrial wastes have been separated so as to give a better picture of the situation. The total estimated population equivalent of the untreated wastes of communities and industries along the streams of the

St. Vrain system is 748,000, of which number 718,000 are attributable to seasonal industrial wastes, principally from the beet sugar industry.

Table SV-2 **Sources of Pollution - St. Vrain Creek Subbasin**

Community	Stream	River Mileage Above Mouth	Sewered Population	Type of Treatment (1)	Estimated Population Equivalent (BOD)	
					Untreated	Discharged
Industrial Waste	St. Vrain	SV 27.5	--	None	60	60[a]
Industrial Waste	St. Vrain	SV 27.0	--	None	18,000	18,000[b]
Longmont	St. Vrain	SV 26.8	8,000	S	8,000	3,200[c]
Industrial Waste	St. Vrain	SV 26.0	--	None	700,000	700,000[d]
Boulder	Boulder	SV-Bo 19.6	21,000	P	21,000	13,650
Lafayette	Coal	SV-Bo-Co 12	1,000	P	1,000	700

(1) P - Primary Treatment. S - Secondary Treatment.
a Intermittent discharge.
b Seasonal, June-October.
c No secondary settling provided.
d Seasonal, October-December.

The estimated population, excluding these wastes, is 30,000, which represents the untreated domestic sewage load of communities along the streams in this subbasin. The sewage from all sewered communities receives some type of treatment before discharge to the stream. Only one city, Longmont, provides secondary treatment but, since no secondary settling is provided following the trickling filters, humus from the filters is discharged with the plant effluent. This partially nullifies the effect of treatment since this material places a heavy organic pollution load upon the receiving stream. Secondary settling should be provided.

Other communities provide primary treatment for their sewage before discharge to the streams. It is estimated that the population equivalents are reduced from 22,000 to 14,350 by this treatment. During a portion of the time of this survey, sewage from Boulder was bypassed directly to the stream because of repairs to the treatment plant.

Industrial waste pollution is concentrated about the City of Longmont where a large cannery and a beet sugar factory are located. Both of these industries are seasonal. A small slaughterhouse is located on the main stream west of the city, and the operation is intermittent.

All of the above discharge raw wastes to the stream with little or no treatment. There are 19 producing coal mines located in the basin. They are centered around the communities of Louisville, Lafayette, and Erie. There appears to be little or no wastes from the mines and no coal washing is done. Table SV-3 below summarizes the industrial pollution in this sub-basin.

Table SV-3 Industrial Waste Summary

Industry	Stream	No. of Plants	Estimated Population Equivalent (BOD)
Cannery	St. Vrain	1	18,000
Beet sugar	St. Vrain	1	700,000
Slaughterhouse	St. Vrain	1	60
Ore mill	South Boulder	1	-
Coal mines	Boulder and Coal	19	-

Laboratory Results

Fig.SV-1 shows the location and magnitude of the pollution sources on the St. Vrain Creek system, together with the location of irrigation diversions and a graphical presentation of average laboratory results of dissolved oxygen, BOD, and coliform count for summer and winter seasons. These data are also shown on Figures 6, 8, and 10, and on Figures 7, 9, and 11 for summer and winter seasons, respectively. The values as shown on the above Figures are averages and do not represent the most critical conditions at any given point. Reference is made to the summary of individual results in Appendix "J" for more detailed information.

Dissolved Oxygen

Dissolved oxygen results are good in the St. Vrain above Longmont and in Boulder Creek above Boulder at all seasons of the year. In the St. Vrain, winter results show an oxygen sag below Longmont due to the heavy pollution from beet sugar processing. Recovery to near saturation level is apparent near the stream mouth. In summer, the depression in dissolved oxygen below Longmont is of lesser magnitude but little recovery is apparent in the stream to the mouth.

In Boulder Creek there is a sharp sag in the dissolved oxygen level immediately below the treatment plant during the winter period with rapid recovery. The summer results do not show such a sag but the samples were taken further downstream. Also dilution was higher in the summer months at the sampling point.

B.O.D. Results

An increase in average BOD of about 4 p.p.m. is recorded below Longmont during the summer period (May - September). In the winter season (October - April) this increase rises to a value of 261 ppm. There appears to be little reduction in BOD in the stream below

Longmont in the summer period. A considerable reduction occurs in the winter season.

A sharp increase in average B.O.D. is shown in Boulder Creek below the City of Boulder during the winter season with subsequent reduction downstream. In the summer period the average B.O.D. shows a rise of much less magnitude below the city with relatively little recovery downstream.

Coliform Results

Median coliform numbers, for the summer season, show a marked rise at Longmont to about 300,000 per 100 ml. This value decreases to about 60,000 near the mouth of the St. Vrain. In the winter period the median coliform numbers increase to about 43,000,000 per 100 ml. below Longmont because of beet wastes. A reduction from this value to about 20,000 per 100 ml. is recorded near the stream mouth.

Increases in median coliform counts occur in Boulder Creek below the City of Boulder. The winter results show a much higher count than do those for the summer period. The residual counts in the downstream stretch appear to maintain themselves at about the same magnitude for both summer and winter seasons.

Chemical Results

Copper is present in the St. Vrain system in maximum amounts of about 0.1 ppm. Hardness values increase rapidly in the St. Vrain in the vicinity of Longmont and below. Maximum values reach about 800 ppm. This increase in hardness is probably the result of return waters leaching chemicals from the soil. Hardness of waters in Boulder Creek is low with values of less than 100 ppm.

Low-Flow Frequencies

Table SV-4 summarizes a study of low-flow frequencies at three gaging points on the system. Periods of record vary from 56 to 21 years. The low-flow frequencies were calculated for the periods from May to September and from October to April. The Boulder Creek gage is located near the mouth of the stream.

DISCUSSION

Waste Treatment Status and Needs

Sewage

The bulk of the sewage in this sub-basin is contributed by two communities, Longmont on the St. Vrain and Boulder on Boulder Creek. Some sewage is contributed by Lafayette to Coal Creek, a tributary of Boulder Creek.

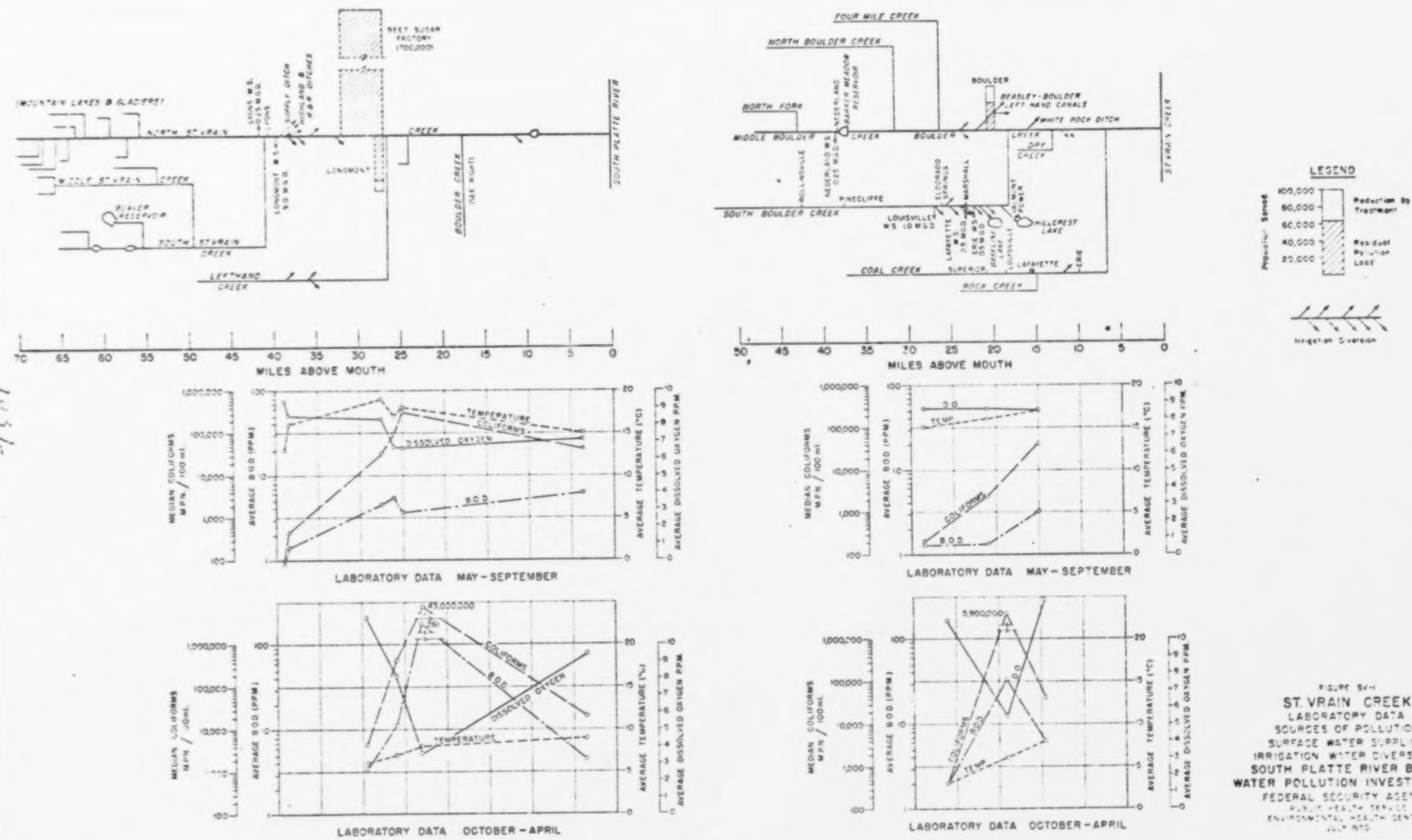

FIGURE SV-1

ST. VRAIN CREEK
LABORATORY DATA
SOURCES OF POLLUTION
SURFACE WATER SUPPLIES
IRRIGATION WATER DIVERSIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

1936

Table SV-4

Frequency of Low Mean Monthly Discharges

ST. VRAIN CREEK

Stream and Gaging Station Location	Miles above Mouth		Drainage area in sq.miles	Years of Record	Value in cu. ft. per second which the mean monthly flow may be expected to equal or be less than on the average of once in:								Low mean month of record in cubic feet per second	
					2 years		3 years		5 years		10 years			
	St. Vrain	Tributary			summer[1]	winter[2]	summer	winter	summer	winter	summer	winter	summer	winter
St. Vrain near Lyons	33.4		226	56	75	6.6	65	5.9	56	5	45	3.9	21.9	3.1
St. Vrain near Platteville	1.		1,000	22	61	34	55	28	49	22	45	17	22.7	24.4
Boulder Cr. near mouth	17.4	1.5	512	21	1.8	1.7	1.5	1.4	1.3	1.3	1.	1.2	1.2	1.1

1 - Summer irrigation season: May 1 to September 30.

2 - Winter non-irrigation season: October 1 to April 30.

Boulder contributes the largest volume of sewage after providing primary treatment. During 1949 there were several periods when the treatment plant was by-passed for the purpose of making repairs. A temporary lagoon was constructed to provide about four hours' detention time during the longest periods of shutdown from April 5 to May 9, and from July 7 to July 27. Although the plant effluent as discharged to the stream was in sufficient volume to give the entire creek a characteristic "laundry waste" color and provide a characteristic "sewage" odor, there was little evidence of either condition at points 3 or 4 miles below the outfall. On numerous occasions the odors emanating from the Boulder sewage treatment plant were pronounced and were noticeable for some distance downwind from the plant site. Whether these odors resulted from the temporary lagoons or from conditions in the settling tanks was not determined. The Colorado State Department of Health conducted some investigations with regard to the adequacy of the Boulder treatment plant, and the City of Boulder has employed a consulting engineer to conduct similar investigations. The results of the State Health Department show that the average sewage flow during the period of investigation in the winter of 1950 was 2.3 MGD, and the average strength of the wastes was about 225 ppm. Minimum stream flow recorded at a sampling station about 1/2 mile below the plant during the period from November to April was 7 cfs. This would provide for a dilution ratio of 2:1, based upon the average sewage contribution of 2.3 MGD (3.6 cfs). The low mean monthly flow frequencies recorded in Table SV-4 are those expected at a gaging station located near the mouth of Boulder Creek. This station is below irrigation diversions, and the recorded values are not representative of the actual stream flows found in the vicinity of Boulder sewage treatment plant. This table also indicates that there is very little variation in the minimum flow frequencies to be expected for any time interval. During winter low-flow conditions, the BOD values in the stream show a marked increase resulting from the discharge of Boulder sewage. This demand is apparently satisfied in the stream at a relatively high rate. The rocky stream bed and the swift current provide considerable opportunity for aeration. Boulder should provide secondary treatment and the plant effluent should be chlorinated.

The Longmont sewage disposal plant provides for secondary treatment. Provision for secondary sedimentation following the trickling filters has been omitted. This should be corrected. Further, chlorination of the effluent should be provided in order to reduce the bacterial contamination in the stream.

The sewage disposal plant at Lafayette is a new installation of unusual design which serves approximately one-half of the community and which provides for primary treatment. Secondary treatment and effluent chlorination should be provided.

Industrial Wastes

The major pollution contributed to this subbasin is provided by the discharge of industrial wastes in and near Longmont. These wastes have an estimated population equivalent in excess of 700,000. Fortunately, these industries operate on a seasonal basis. The bulk of the pollution load is contributed during the months of October to December by the beet sugar factory located immediately east of Longmont. The wastes from this plant have a profound effect upon the receiving waters; odors and other nuisance conditions are prevalent in the stream during this period from the point of discharge of these wastes to near its confluence with the South Platte River. The elimination of silo drainage, Steffens wastes, and lime wastes would probably reduce the strength of the present wastes about 60%, and the re-use of process waters would result in a further reduction of 20% in the population equivalent. (Refer to Appendix "F"). The cannery wastes are discharged directly to the stream without treatment, except for haphazard screening. It would be advantageous for the wastes from the cannery to be treated in the municipal sewage treatment plant. However, this would probably require an addition to the present plant in order to handle these wastes. In any event, pollution by the cannery wastes should be abated.

Irrigation Usage

In this subbasin, irrigation diversions are located largely along the Boulder Creeks, more especially along South Boulder below Eldorado Springs. Most of the diversion along the St. Vrain occurs in the stream stretch between Lyons and Longmont. There is no irrigation diversion for about 15 miles below Longmont. Diversions occur on Boulder Creek approximately 4 to 9 miles below the point of discharge of the Boulder sewage treatment plant. Table SV-5 presents a summary of the laboratory results of samples taken at the intakes of representative irrigation ditches in this subbasin during the summer season of 1949.

Table SV-5 Summary of Laboratory Results - Irrigation Diversions - Season 1949

Station	Number Samples	Value	Dissolved Oxygen		BOD	Coliform Bacteria per 100 ml (MPN)
			ppm	% Sat.	ppm	
Highland Canal SV 38.4	11	Avg.	8.5	103	1.4	430*
		Max.	9.3	109	2.4	11,000
		Min.	7.4	96	0.7	23
Beasley Ditch Bo 21.0	11	Avg.	8.6	105	1.3	2,400*
		Max.	9.4	111	2.1	15,000
		Min.	7.9	100	0.8	230
White Rock Ditch Bo 15.0	11	Avg.	8.5	106	3.2	43,000*
		Max.	9.7	117	5.0	460,000
		Min.	7.9	97	1.5	14,000

* Median coliform count instead of average.

In general, the sanitary quality of water available for irrigation purposes above major sources of pollution is satisfactory.

Recreational Use

Headwater streams in this basin are used extensively for fishing and recreational purposes, especially the Boulder Creek areas. The upper Boulder Creeks are the sites of early-day gold mining operations. There are a number of cabin communities, camps, parks, and ranches located in the headwaters areas. Towns of Nederland and Eldorado Springs are largely tourist and recreational centers during the summer months. In that these streams are used as sources of public water supplies, care should be exercised to prevent undue pollution from careless wastes discharges to the streams. South Boulder Creek is utilized for some distance to transport the Moffat Tunnel water for the Denver Water Supply en route to Ralston Reservoir. No direct discharge of raw sewage to the streams in these areas should be condoned and ample provisions should be provided for the disposal of wastes from campers and other visitors using these areas.

Probable Effects of Project Operations

The Colorado-Big Thompson Project will deliver project waters to the St. Vrain Creek at a point near the western city limits of Lyons (SV-40) in accordance with a contract between the Bureau of Reclamation and the Northern Colorado Water Conservancy District. The Bureau of Reclamation estimates that the increase in stream flows due to the Colorado-Big Thompson operation in the St. Vrain Creek at the delivery point will be as follows:

Month	Project Water		Recorded Minimum Monthly Avg. at Lyons Gage, c.f.s.
	Acre-feet	Avg. c.f.s.	
June	9,443	157	178
July	9,547	159	81
August	15,553	259	41
September	12,475	208	22
October	4,174	70	10

The values given in the above table represent the average increase from project operation, as nearly as can be determined, at the immediate point of delivery. There will be no increase at these points for the months of November through May, since all return flows will appear below these points. The increase below the points of delivery will vary, depending upon the amount of project water diverted above any particular point and upon how much flow from project waters has returned to the stream above that point. The Bureau of Reclamation estimates that the increased flows at Longmont resulting from the operation of the Colorado-Big Thompson Project will be as follows:

Month	Increase flows (c.f.s.)	Month	Increase flows(c.f.s.)
January	8	July	10
February	8	August	12
March	8	September	12
April	8	October	12
May	8	November	8
June	12	December	10

The Colorado-Big Thompson Project may deliver some project water to Boulder Creek. However, the amount and the point of delivery are still undecided. Imported water to Boulder Creek will result from the construction of the proposed Blue-South Platte Project, should this project be authorized. Only a small portion of the Blue-South Platte Project supply would be delivered directly to Boulder Creek. Most of the supplemental water would be delivered to South Boulder Creek or directly to irrigation ditches. It is estimated that the increased flows in Boulder Creek would average 25 second-feet during the summer months. All of this water would be rediverted from the stream above the confluence with South Boulder Creek.

Need for Water Conservation Measures

Remarks concerning the increased stream flows in the St. Vrain Creek at points below the delivery point also apply to the Boulder Creek system. In common with the water in other areas of the South Platte Basin, these waters have an unusually high value. This is because the limited water supply must be utilized to satisfy all of the demands placed upon it. The need of water for irrigation purposes in order to maintain a well diversified agriculture places a terrific demand upon every available acre-foot of runoff. The lack of sufficient water suitable for agriculture could lead to the abandonment of established agricultural pursuits in the basin. After domestic water needs have been met, the economy of the region would require that agricultural needs must be satisfied with water of a suitable quality for agricultural purposes. The abatement of water pollution would afford economic insurance through the continued maintenance of suitable agricultural water quality.

THOMPSON RIVER SUBBASIN

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THOMPSON RIVER SUB-BASIN

SYLLABUS

Big Thompson River arises in the area embraced by the Rocky Mountain National Park. It has a drainage area of about 842 square miles including that of the Little Thompson which joins the main stream at Milliken, Colorado.

All incorporated communities in the basin use surface waters as their source of public water supplies. Water treatment provided ranges from partial to complete. Two communities provide rapid sand filtration; one provides coagulation, sedimentation and disinfection only; one provides for chlorination of a portion of its supply. Total population served is estimated as 11,000 and the combined capacity of all plants is 11.5 MGD.

Major water usage in the basin is for irrigation. Recreational use of the headwaters area above Loveland is considerable and extensive development of the area has been undertaken for this purpose. Adequate safeguards are required to prevent undue pollution of waters used as sources of public water supplies.

Wastes having an estimated total population equivalent of 670,000 are discharged to the streams in the basin. Of this amount 640,000 is contributed by a beet sugar factory at Loveland. Waste load from this plant should be materially reduced by changes being made in the plant operations. Of the remaining wastes, nearly half of the load is contributed by canneries.

Two towns with population equivalent of 1,700 discharged raw sewage into the streams. Five treatment plants serving four communities provide secondary treatment for a population equivalent of about 14,000. Secondary settling should be provided at 4 of these plants to increase the over-all plant efficiencies.

Increased summer stream flows are expected to result from project operations of the Colorado-Big Thompson Project. Material increases are anticipated at Loveland during this period which will increase available dilution water at that point. Winter flow increases will be of a relatively low order and will have no benefit in reducing the effects of current industrial waste problems.

CONCLUSIONS

1. Surface water sources are used by public water supplies serving incorporated communities in this basin. There are 4 supplies serving about 11,000 persons and having a combined capacity of 11.5 MGD. All supplies receive some sort of treatment before use, ranging from simple chlorination to complete treatment.

2. Two communities with a combined population of 1,700 discharge raw sewage to the streams. Remaining communities serving an estimated 10,000 persons provide sewage treatment. Secondary settling provisions are required by 4 plants.

3. One industrial waste loading of 640,000 population equivalent is discharged to the river at Loveland from October to December. This loading will be reduced by current changes in plant operations. Canneries in the basin contribute an estimated 15,000 population equivalent to the streams during the late summer and fall.

4. Water quality in the headwater streams is good. The effects of sewage and wastes discharges are manifest in the lower reaches of the stream.

5. Increased stream flows are anticipated during the summer months as a result of operations of the Colorado-Big Thompson Project. These flows should be of intangible benefit to Loveland. Increased winter flows will be of a low order and will not contribute much towards the lessening of the current stream pollution requirements.

RECOMMENDATIONS

1. Water quality should be protected to the extent required for reasonable water use by provision, as necessary, of sewage treatment, including adequate chlorination.

2. Secondary settling tanks should be installed at 4 treatment plants not now provided with them.

3. Adequate waste treatment or reduction or both should be provided for industrial wastes as necessary to protect downstream water quality and use.

4. Provision should be made for adequate protection of water supply sources used for recreation or other activities, with special emphasis on adequate treatment of sewage wastes being of paramount importance. The increasing use of the headwater regions of this basin for recreational purposes will require strict supervision of sanitation installations to assure adequate protection.

5. More complete water treatment should be provided at Johnstown.

6. Both water supply sources at Estes Park should be chlorinated before use. Filtration of the water before use should be given consideration in the light of increasing usage of the catchment areas for recreational purposes.

DESCRIPTION

The Big Thompson River, often called the "Thompson," rises along the eastern slope of the Continental Divide in Rocky Mountain National Park at elevations in excess of 12,000 feet. The main stem flows generally eastward from its source to its junction with the South Platte River above LaSalle, Colorado. The Little Thompson somewhat parallels the main stream, which it enters at Milliken, Colorado, about 5.5 miles above the mouth. The Big Thompson, for the upper half of its length, flows through rugged mountainous country of great scenic value. The region is highly prized as a summer resort area. Above Estes Park the waters flow through the Rocky Mountain National Park; below Estes Park the river flows for about 20 miles through a narrow canyon of considerable scenic beauty. This canyon is the site of numerous cabins and resorts which support a considerable population in the summer months. The waters in the canyon and above are much used for fishing during the season.

The Big Thompson River is about 80 miles long and has a drainage area of 842 square miles. The stream bed is rocky with slopes of 100 feet or more per mile above the canyon mouth. In the plains area, the stream bed is in a sandy-gravel formation and the slope decreases to about 10-15 feet per mile.

The largest community on the Big Thompson is Loveland, Colorado, a tourist and farming center of about 8,000 population located below the Thompson Canyon. Other communities are Estes Park, a resort center near Rocky Mountain National Park, and Milliken, a farming community near the mouth of the river. Berthoud and Johnstown are communities located on the Little Thompson. Both are small farming communities.

Climatic conditions in the Big Thompson River Subbasin are similar to those described in the General Section on the South Platte River. Winter weather conditions in the headwaters are quite severe, summers are mild, and snowfall is generally lighter than that which occurs on the western slope of the Divide. In the plains area, the summer and winter temperatures are extreme, rainfall is light, and relative humidity is generally low.

PRESENTATION OF DATA

Public Water Supplies

All incorporated communities in this subbasin use surface waters as sources of public water supply. Table T-1 on the following page summarizes the supplies for these communities.

Loveland obtains its water supply directly from the Big Thompson River in the Thompson Canyon. The canyon watershed is patrolled, but there are a great number of cabins and resorts located along the contributory watershed. A permit system for private sewage disposal systems has been inaugurated in the Larimer County area and should aid in the control of this type of construction. A scavenger system is provided by the city for handling material from the chemical toilets and closed pit privies. A few of the larger resorts have septic tanks. The effluent from these tanks is required to be chlorinated before discharge into the waters of the Thompson River. However, in many instances the contact time is insufficient for adequate disinfection. The use of sand filters should be required as a secondary treatment for the septic tank effluents from this area. Most of the water supplies for this resort area are obtained from shallow wells, and the water quality is not always satisfactory. Laboratory results of samples taken from the Thompson River in the vicinity of the Loveland waterworks intake show that, despite the heavy use of the canyon for resort purposes, the bacteriological quality of the water in the river at the intake is relatively good and should not offer any obstacle in producing a safe water by the method of treatment in use by the City of Loveland. The water supply of Loveland is treated by means of complete rapid sand filtration, followed by disinfection with chlorine.

Table T-1 - Public Water Supplies from Surface Sources
Thompson River Subbasin

Community	Watershed	Source	Estimated Population Served (1949)	Treatment	Capacity M.G.D.
Estes Park	Thompson	(1) Glacier Creek (2) Black Canyon	1,200*	Chlorination None	1.0 1.0
Loveland	Thompson	Thompson River	8,000	Rapid sand filtration Chlorination	6.0
Berthoud	Little Thompson	Thompson River via Handy Ditch	900	Rapid sand filtration Chlorination	2.0
Johnstown	Little Thompson	Thompson River via Home Supply Ditch	1,000	Coagulation, Sedimentation, Rapid Sand Filt. Chlorination	1.5

* Summer population estimated 6,000.

Water supplies for Berthoud and Johnstown are also obtained from the Thompson River by way of irrigation ditches which have their intakes near that of the Loveland water supply. The quality of water entering these ditches is comparable to that at the Loveland intake. The town of Berthoud provides complete rapid sand filtration and disinfection by chlorination for its water supply. The town of Johnstown provides coagulation, sedimentation, rapid sand filtration, and disinfection.

Sources of Pollution

Table T-2 summarizes the magnitude and location of significant sources of pollution discharged to the Thompson River and tributaries. Sources of industrial waste pollution are shown, as well as those for domestic sewage. This has been done in order to separate the seasonal industrial waste discharges from those which present a constant source of pollution. The total population equivalent of all wastes in the sub-basin is estimated at 670,000; 640,000 of this number is contributed by the beet sugar factory at Loveland during the months from October through December. Of the remaining 30,000 population equivalent, approximately one-half is contributed by canneries which operate mostly during the summer months. The towns of Johnstown and Milliken discharge their domestic sewage into the receiving streams without treatment. The sewage from a population equivalent of approximately 1,700 is discharged raw into the waters of the Little Thompson and Thompson Rivers. The sewage from a population equivalent of about 14,000 receives treatment before discharge to the stream. This treatment reduces the population equivalent to approximately 4,160. This reduction would be materially improved if secondary settling were provided at several of the plants.

Table T-2 Sources of Pollution - Thompson River Sub-Basin

Community	Stream (1)	River Mileage Above Mouth	Sewered Pop.	Type of Treatment (2)	Estimated Population Equivalent BOD	
					Untreated	Discharged
Bureau Reclamation Camp	T	T 56.5	300	S	300	120[a]
Estes Park	T	T 55.3	850[b]	S	850[ab]	340[ab]
Ind. Waste	B	T-Bu. 1.4	--	None	1,560	1,560[c]
Ind. Waste	T	T 30.3	--	None	2,500	2,500[c]
Ind. Waste	T	T 23.0	--	None	9,600	9,600[d]
Loveland	T	T 22.9	2,000	S	2,000	800[a]
"	T	T 22.7	6,000	S	9,750	2,500
Ind. Waste	T	T 21.0	--	None	640,000	640,000[e]
Berthoud	LT	T-LT 12.8	1,000	S	1,000	400[a]
Ind. Waste	LT	T-LT 2.0	--	None	460	460[f]
Johnstown	LT	T-LT 2.0	1,200	None	1,200	1,200
L. Thompson R.	T	T 5.5	--	--	--	--
Milliken	T	T 5.5	500	None	500	500

(1) T - Thompson River; B - Buckhorn Creek; LT - Little Thompson River.
(2) P = Primary Treatment; S = Secondary Treatment.

a - No secondary settling provided.
b - Summer population estimated 6,000
c - Seasonal - Cherry season - July.
d - Seasonal - August to September.
e - Seasonal - October to December.
f - Johnstown Sewer System.

The major industrial waste load is concentrated about the town of Loveland with the sugar beet factory providing the greatest contribution. Of the canneries in the basin, the majority process cherries during a rather short season, usually in July of each year. For the most part, the fruit is prepared for cold pack which entails preparation for quick freezing. A large cannery at Loveland discharges raw wastes to the Thompson River, but other canneries located in the city discharge to the city sewage treatment plant. Table T-3 below summarizes the industrial waste pollution in the Thompson River Basin. Figure T-1 shows graphically the location and magnitude of sources of pollution, together with the points of irrigation diversion along the Thompson River system. Average laboratory results for the summer and winter seasons are also shown.

Table T-3 Industrial Waste Summary - Thompson Sub-Basin

Industry	Stream	No. of Plants	Estimated Population Equivalent (B.O.D.)
Cannery[a]	Thompson River	4	13,100
Cannery[b]	Buckhorn Creek	1	1,560
Beet Sugar[c]	Thompson River	1	640,000
Condensed Milk	Little Thompson R.	1	460

a - Seasonal operation June - September.
b - Seasonal operation - July.
c - Seasonal operation October - December.

Laboratory Results

The laboratory results covering determinations of dissolved oxygen, B.O.D., and median coliform counts are shown graphically on Figures 6, 8, and 10 for the summer season from May to September, and on Figures 7, 9, and 11 for the winter season from October to April. The values presented in these figures are averages and do not show the most critical conditions at any given station. For this information, reference is made to the Summary of Individual Results appearing in Appendix "J" or to the Summary of Seasonal Results in Table 34 of the General Section.

Dissolved Oxygen

The levels of dissolved oxygen in the Thompson Rivers during the summer season are high, being in excess of 90% saturation at all sampling points. During the winter season the oxygen levels in the Thompson River above Loveland are quite good. Below the city, however, the oxygen levels are depressed noticeably and remain so for some distance downstream. Below the junction with the Little Thompson at Milliken some oxygen recovery is evidenced in the stream. This oxygen sag below Loveland during the winter period is the result of beet wastes discharged to the stream during the operation of the sugar plant below the city.

B.O.D. Results

The average B.O.D. results of the stream samples above Loveland are generally low. During the summer period a relatively marked increase in B.O.D. is recorded below Loveland. This increase persists in the stream to its junction with the Little Thompson, at which point there is a sharp decline. During the winter period the average B.O.D. increases to a value of 200 ppm below Loveland, which result reflects the influence of the wastes discharged from the Loveland beet sugar factory. B.O.D. values remain high in the stream from here to the mouth. In the Little Thompson, there is a sharp increase in B.O.D. below Johnstown both in summer and winter periods. The magnitude of this increase during the winter period is much greater than that occurring in the summer season. The reason for this sharp increase in the winter is not apparent. The beet sugar factory at Johnstown, operating on a special barium recovery process, should not normally produce wastes which would create a high degree of pollution.

Coliform Results

The median coliform values in the Thompson River above Loveland are well under 1,000 per 100 ml during the winter season. During this season the bacterial quality of the water below Loveland, however, is not good, as indicated by a median coliform value of about 400,000 per 100 ml. A considerable decrease in bacterial numbers in the stream stretch between Loveland and Milliken is evidenced by the median coliform value of 1,000 per 100 ml. immediately above Milliken. The discharge of raw sewage by the community of Milliken is evidenced by the increase in coliforms below the city which persists to the mouth of the stream.

During the summer season the median coliform values above Estes Park are below 100 per 100 ml. The increase in summer population in the Estes Park area is reflected by an increase in the median coliform value to 2,300 per 100 ml. at the outlet from Estes Reservoir. This value is maintained throughout the Thompson Canyon area probably as a result of the recreational use of this area during the summer period. Coliform counts in the river below Loveland are high throughout the remaining length of the stream.

In the Little Thompson River the median coliform values are high during both summer and winter periods, with median values of 400,000 per 100 ml. below Johnstown, and values in excess of 10,000 per 100 ml. above the city. High coliform counts are consistently recorded at all sampling stations on the Little Thompson River.

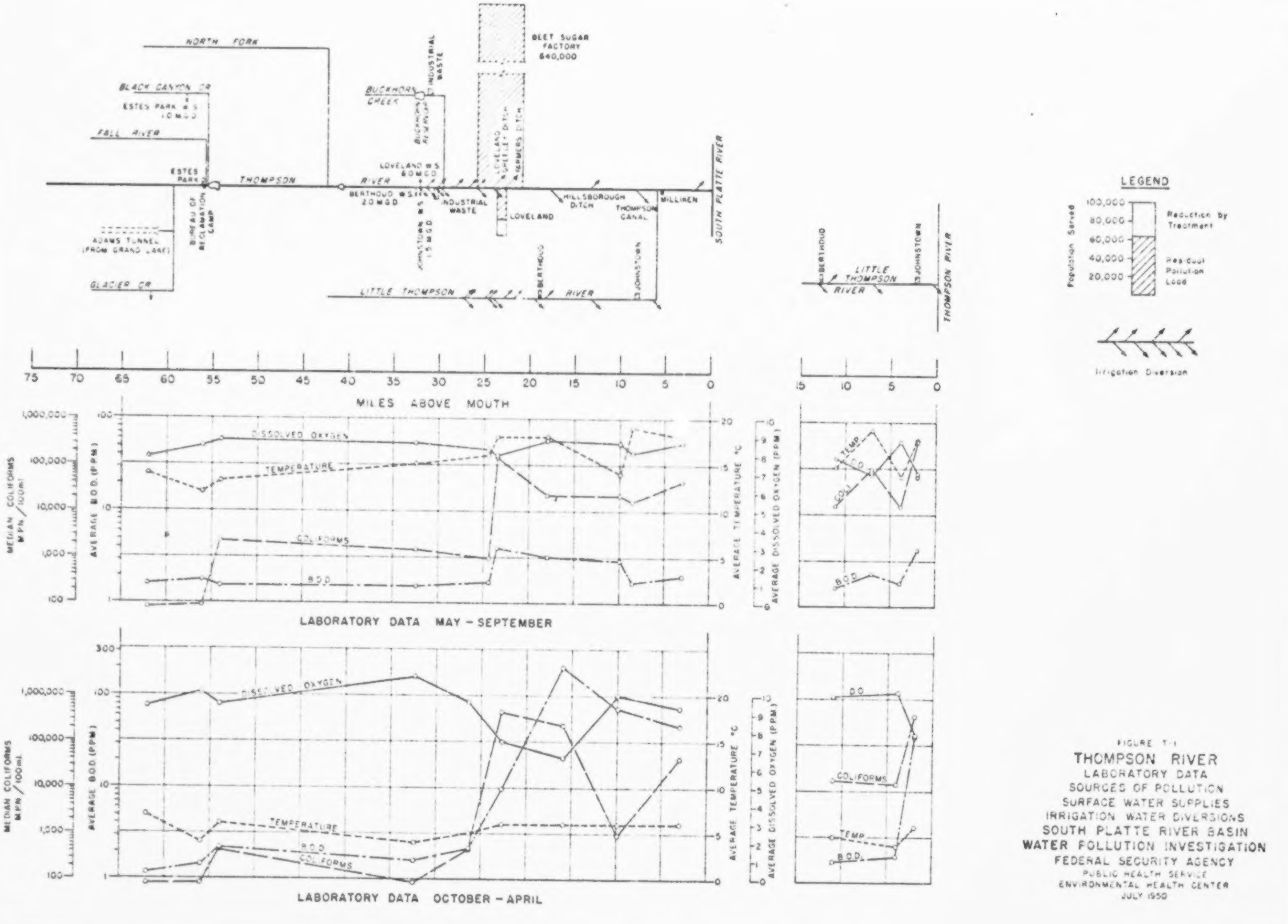

FIGURE T-1

THOMPSON RIVER
LABORATORY DATA
SOURCES OF POLLUTION
SURFACE WATER SUPPLIES
IRRIGATION WATER DIVERSIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

GPO 83-472578

Chemical Results

Copper was investigated because of its effects on the B.O.D. determinations when present in amounts in excess of .01 ppm. Copper contents of samples taken from the Thompson River at stations above Loveland show maximum concentrations in excess of .1 ppm. This value decreases somewhat below Loveland where maximum values were .07 ppm. Values of hardness and alkalinity obtained from samples taken above Loveland were quite low, being of the order of 50 ppm. and less. There is a sharp increase in hardness and alkalinity in the stream below Loveland. Maximum hardness values in excess of 1,000 ppm. were obtained at the mouth and near its junction with the Little Thompson. Maximum values of near 2,000 ppm. were obtained from samples taken from the Little Thompson River especially during the winter season. This is probably the result of return flows to the stream from irrigation. The increase in chemical content of the water is brought about by leaching through the soil.

Low-Flow Frequencies

Table T-4 summarizes a study of low mean monthly flow frequencies computed from the period of record for 3 gaging stations on the Thompson River. The period of record varied from 18 to 22 years. Low-flow frequencies were computed for the summer season from May to September and the winter season from October to April. The effects of irrigation can be noticed by comparing the mean monthly low flows during the summer months between the gaging stations at Drake and at LaSalle near the river mouth. It will be seen that practically the entire flow of the stream as recorded in the canyon has been diverted before it can reach the mouth of the river.

Table T-4

Frequency of Low Mean Monthly Discharges - Thompson River

Gaging Station Location on Thompson River	Miles Above Mouth	Drainage Area in Square Miles	Years of Record	Values in Cubic Feet per Second which the Mean Monthly Flow May Be Expected to Equal or to Be Less than on the Average of once in:								Low Mean Month of Record in Cubic Feet per Second	
				2 Years		3 Years		5 Years		10 Years			
				Summer (1)	Winter (2)	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Estes Park	68.9	158	18	60	9.3	52	8.2	46	6.6	38	5.5	25	5.9
Near Drake below Loveland Powerhouse	34.5	277	20	82	13	70	12	57	10.5	47	9	40	7.2
LaSalle	1.0	818	22	4.2	12	2.9	6.8	2.0	4.1	0.4	2.6	0	1.5

(1) Summer - Irrigation Season - May 1 to September 30.
(2) Winter - Non-Irrigation Season - October 1 to April 30.

DISCUSSION

Waste Treatment Status and Needs

Sewage

Two cities in the basin discharge raw sewage directly to the streams. These are Johnstown on the Little Thompson River and Milliken on the Thompson River. In addition to their domestic sewage, the wastes from a condensed milk plant are discharged to the stream through the Johnstown sewer system. The total population equivalents are estimated at about 1,700 for Johnstown and at 500 for Milliken. Both of these communities should provide secondary treatment plus effective chlorination for their sewage before discharging to the receiving streams.

The major water pollution problem in this subbasin is concentrated in the vicinity of Loveland. The domestic sewage from the city and the wastes from two canneries are given secondary treatment before being discharged to the Thompson River. Loveland provides two plants for this purpose. One plant is a conventional Imhoff tank-trickling filter installation which handles the sewage from a population of about 2,000. The other and more modern plant provides sedimentation, separate sludge digestion, high-rate filter, and secondary sedimentation. This plant handles the domestic sewage from a population of approximately 6,000, together with the industrial wastes from two canneries which have an estimated population equivalent of 3,750. Since the older plant does not provide for secondary sedimentation following the trickling filter, its efficiency is reduced. Further, this plant is not as well maintained and operated as the newer installation. Secondary sedimentation and better operation should be provided at this installation to improve plant efficiency. In view of the fact that waters from the stream are diverted below Loveland for irrigation purposes, chlorination of the effluent is needed at both plants.

The communities of Estes Park and the Bureau of Reclamation Camp, located above Estes Reservoir, both provide treatment for their sewage. In each case, there is no secondary settling provided following the trickling filters. This deficiency should be corrected. Failure to provide secondary settling decreases the over-all plant efficiency and interferes with efficient effluent disinfection. Both of these plants also provide for chlorination of the final effluent. In neither case is a suitable contact basin provided so as to obtain the maximum effectiveness from the chlorine before the effluent is discharged to the stream. Inasmuch as the waters of Estes Reservoir are to be extensively used for recreational purposes and it is anticipated that eventually provision will be made for a bathing beach along the shore line relatively close by the Bureau of Reclamation treatment plant, it is important that efficient disinfection of the effluent from this plant be provided. The same may be said for the effluent of the Estes Park plant, although it is not located directly upon the lake. The effects of sewage discharged from these two plants is apparent in the sharp rise of coliform organisms between stations above Estes Park and at the outlet to

Estes Reservoir. One solution to this problem might be the treatment of sewage from the Bureau of Reclamation Camp in the Estes Park municipal sewage treatment plant. This would involve the installation of a pumping station to handle the sewage from the camp. During the winter months the trickling filters at the Estes Park plants are not used because the low temperatures cause them to freeze. The population loadings on the plants are greatly diminished during the winter season. Arrangements should be made for year-round plant operation.

The only other sewered community in this river system is Berthoud, located on the Little Thompson River. The domestic sewage from this community is treated by means of a sewage treatment plant providing a conventional Imhoff tank - trickling filter installation. No settling basin is provided following the trickling filter. It is recommended that secondary settling and chlorination of the final effluent be provided.

Industrial Wastes

The major industrial waste load is created by the beet sugar factory located immediately east of Loveland. This plant has a population equivalent estimated at 640,000. The effluent has a profound effect upon the stream, causing oxygen depletion for a considerable distance during operation. It is anticipated that the population equivalent of these wastes will be materially reduced in the near future because extensive alterations are being made to the Loveland plant by the management. These changes will involve the installation of a pulp drier and of equipment designed to utilize certain process waters for re-use after chemical treatment. There is also under consideration a proposal to install sufficient evaporation capacity to evaporate Steffens wastes for use as a feed supplement. These changes in the plant should remove the silo drainage, the Steffens wastes, and the process water. The removal of these constituents probably will account for 70% reduction in population equivalent during the next season. This will represent considerable progress but the residual pollution load will be considerable and will need still further reduction. The Loveland plant is being used as an experimental project, designed to apply on a plant scale the known methods for reduction of beet sugar wastes.

There are a number of canneries operating in this subbasin, most of which are for the purpose of processing the cherries produced in this area. The season of operation is very short, usually not extending for more than a month. Most of the cherries are processed for quick freezing. A vegetable cannery is located in Loveland which operates from June to September. The wastes from this cannery are discharged directly to the Thompson River after haphazard screening. Silo drainage resulting from the stacking of pea vines also enters the wastes from this cannery.

During a portion of the 1949 season, some of the wastes were being discharged to an irrigation ditch as the result of poor maintenance of the sewer outfall from the plant. The only remaining industry which discharges wastes to the watercourse is a condensed milk plant located in Johnstown on the Little Thompson River. The wastes from this plant are discharged to the sewer system of Johnstown. A meat packing plant is located south of Loveland, but none of the wastes are discharged directly into the stream. Wastes from this plant are discharged to septic tanks which have subsoil drainage fields.

In the cases of those industries which are now discharging untreated wastes to the watercourses, means should be provided for the abatement of this pollution. A practical and economical solution would be for the industry to discharge its wastes through a municipal sewage treatment plant, provided the wastes could be handled by the plant without difficulty. Where an industry is so located that this solution to the problem is not possible, the industry should provide some type of waste treatment for pollution abatement purposes. The type of treatment to be used by any given industry would depend upon the nature of the industry and the characteristics of its wastes. In the case of those industries which have seasonal operation, such as canneries, the method of waste treatment becomes more involved in that the period of waste production is short and the cost of treatment works is high in proportion to the time they are in use. Further, where wastes high in organic content are produced, biological methods are not suitable because the operating season is too short to permit development of optimum efficiency. In such instances, lagooning of the wastes during the operating season is quite common as a method of disposal where suitable areas are available for the construction of lagoons. One difficulty with lagoons is the fact that they are often sources of considerable odor nuisance. Odor difficulties can be controlled somewhat by the use of certain chemicals which may be added to the wastes as they are lagooned.

Irrigation Usage

Most of the diversions from the Thompson River for irrigation purposes are taken from the main stream above Loveland. Table T-5 presents a portion of the laboratory results obtained at the intakes of representative irrigation ditches in the Thompson River Sub-basin. The need for chlorination of sewage effluents is reflected in the relatively high median coliform counts at ditch intakes below significant sources of pollution. Stream waters are also diverted for irrigation below Loveland, Milliken, Berthoud, and Johnstown. Chlorination of all sewage plant effluents is recommended.

Table T-5 Summary of Laboratory Results at Irrigation Diversions
Irrigation Season 1949

Station	Number Samples	Value	Dissolved Oxygen		BOD	Coliform Bacteria
			ppm.	% Sat.	ppm.	per 100 ml. (MPN)
Handy Ditch T 32.3	11	Avg.	8.7	102	1.5	1,500*
		Max.	9.7	107	2.4	4,600
		Min.	7.4	91	0.9	430
Loveland-Greeley Canal T 24.3	8	Avg.	8.3	100	1.7	930*
		Max.	9.0	105	2.4	2,400
		Min.	7.6	86	1.2	430
Farmers Ditch T 23.3	12	Avg.	8.0	100	4.0	150,000*
		Max.	8.8	108	12.0[a]	2,400,000[a]
		Min.	7.1	95	1.6	9,100
Hillsborough Ditch T 17.9	10	Avg.	8.8	114	3.2	22,500*
		Max.	11.3	158	12.	110,000
		Min.	7.5	89	1.2	3,900
Big Thompson Canal T 8.5	37	Avg.	8.1	100	1.7	15,000*
		Max.	10.1	128	3.0	460,000
		Min.	6.8	85	1.1	930
Minors Ditch T-LT 7.0	36	Avg.	7.1	90	2.2	93,000*
		Max.	8.6	100	3.3	240,000
		Min.	5.8	73	1.6	23,000

* Median coliform given; not average.
a - Reflects discharge of cannery wastes to ditch.

Recreational Usage

The Thompson River has the most extensive recreational use of any tributary to the South Platte River. It drains from the east slope of the Continental Divide and covers much of the area of Rocky Mountain National Park. Over one million persons visited this area in the 1949 summer season. Streams in the park area and adjacent thereto are heavily stocked for fishing during the season. The Thompson Canyon above Loveland is the site of considerable housing development for summer visitors. Proper wastes disposal is a major consideration in that the waters in the upper canyon serve as the source of water supply for the cities of Loveland, Berthoud and Johnstown.

Two reservoirs of the Colorado Big Thompson Project are located adjacent to the National Park area. These reservoirs are integral parts of the power development portion of the project. They are located immediately adjacent to the town of Estes Park and are in an intensively developed resort area. It is anticipated that extensive recreational use will be made of the reservoir waters of both Marys Lake and Estes Lake for boating, fishing and other aquatic sports. Adequate provisions should be made to prevent contamination of these waters to an extent which would preclude their use for such purposes or which would bring about extensive pollution of the Loveland water supply through use of waters released from these lakes to the Thompson Canyon.

Probable Effects of Project Operations

The Colorado-Big Thompson Project of the U. S. Bureau of Reclamation will deliver project water to the Big Thompson River. It is anticipated that the point of delivery of the supplemental water will be immediately above the diversion point of the Handy Ditch which is about 8 miles above Loveland. There will also be project water delivered to the Little Thompson River at a point near Lyons above all irrigation diversions on that stream. The average increase in stream flows at the points of delivery mentioned above is shown in the following table. These increases are based on the 28-year average, 1920 to 1947, from the utilization studies of the revised report of the Colorado-Big Thompson Project, Bureau of Reclamation.

Table T-6

Estimated Stream Flow Increases
Due to Project Operations

Month	Big Thompson River Estimated Flow Increase		Recorded* Avg. Flow c.f.s.	Little Thompson River Estimated Flow Increase	
	Acre-Feet per Month	Average c.f.s.		Acre-Feet per Month	Average c.f.s.
June	9,300	155	251	603	10
July	12,800	213	189	609	10
August	16,821	280	102	993	17
September	13,275	221	36	796	13
October	4,854	809	35	266	4

* Gage at Drake.

The values in the above table represent the average increase from project operations, as nearly as can be determined, at the immediate point of delivery. There will be no increase at these points in the months from November through May since all return flow will appear below the delivery points. The increase at any area below the points of delivery will vary, depending on the amount of project water diverted above that particular area and upon how much flow from project water has returned to the stream above that area. It is anticipated that the increased flows resulting from the Colorado-Big Thompson Project at Loveland, Colorado, and at the mouth of the Little Thompson River will be as shown on Table T-7.

Table T-7 **Anticipated Flow Increases at Loveland and at Mouth of Little Thompson River Resulting from Project Operations**

Flow Increases in c.f.s.

Month	Big Thompson at Loveland	Little Thompson Mouth	Month	Big Thompson at Loveland	Little Thompson Mouth
January	7	0	July	47	2
February	7	0	August	58	2
March	7	0	September	50	2
April	5	0	October	25	2
May	7	0	November	7	2
June	35	2	December	7	0

The increased flows antipated below Loveland and at the mouth of the Little Thompson will not be sufficient to be of much value in furnishing adequate dilution for the beet processing wastes reaching the stream. In the summer months, the low mean flow frequency value of 57 c.f.s., to be expected once in 5 years, would be increased. This would supplement the present dilution afforded the sewage plant effluent from Loveland. This would be an intangible benefit. This increased dilution, however, would not void the need for chlorination of the Loveland plant effluents.

CLEAR CREEK SUB BASIN

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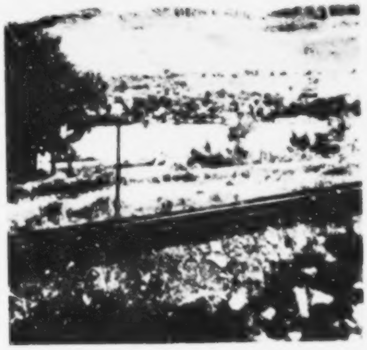
Cl-1 Sources of Pollution, Location of Irrigation Diversions, Etc.. 222

Argo Mill and Tailings Pile,
Clear Creek at Idaho Springs
(Not in operation)



Rocky Mountain Ditch
Diversion, Clear
Creek - Station 16.1

Olympus Dam
(Estes Lake)
Estes Park, Colo.

Sewage Treatment Plant
on Estes Lake.
Estes Park, Colorado

Greeley Water Supply
Diversion, Cache la
Poudre River

Irrigation Diversion,
Cache la Poudre River
Ft. Collins, Colo.

CLEAR CREEK SUBBASIN

SYLLABUS

Clear Creek arises on the eastern slope of the Continental Divide in the vicinity of Berthoud and Loveland Passes in Colorado. The drainage area covers about 600 square miles and the creek joins the South Platte River just north of Denver, Colorado.

The Clear Creek area is the scene of the gold discovery which led to the early settlement of Colorado.

Public water supplies serving an estimated 7,265 persons in 7 communities are obtained from surface sources. Five small communities provide no treatment; the largest community provides chlorination; and the remaining community provides filtration and chlorination.

Major highways parallel the main creeks in this basin and the area is attractive to tourists. Old mining camps thrive on the present-day tourist gold which has replaced that formerly obtained from the now abandoned mines.

Sewage from a population equivalent of 6,070 is discharged to the stream without treatment. One community of 1,400 provides for primary treatment before discharging its sewage to the stream and one sanitation district of 1,200 provides secondary treatment before discharging wastes to the stream.

Industrial wastes with a total population equivalent of 14,900 are discharged to the stream without treatment. These wastes enter the stream from Golden and downstream points.

Major water usage in the basin is for irrigation. A considerable acreage below Golden is used for the production of truck crops, and the numerous diversions deplete the stream flow in the summer months.

Water quality above Golden is quite good but below the city the effects of untreated waste discharges are manifest.

Additional water would be supplied to Clear Creek below Golden from the proposed Blue-South Platte River Project.

CONCLUSIONS

1. Public water supplies serving an estimated 7,265 persons in 7 communities are obtained from surface sources.

2. Total population equivalent of wastes discharged to the basin streams is estimated at 22,000, of which number 14,900 are contributed by industries at or below Golden. The sewage from 6,070 persons receives no treatment before discharge to the streams of the basin.

3. Major water use in the basin is for irrigation. A large part of the truck farming acreage about Denver is irrigated by waters from lower Clear Creek.

4. The effects of the wastes discharges in the stream, particularly below Golden, are indicated by laboratory data.

5. Additional water would be available to the stream in the event the Blue-South Platte Project were authorized. This would not obviate the need for sewage and wastes treatment at Golden or elsewhere along the stream.

RECOMMENDATIONS

1. Public water supplies should be treated as necessary to assure a consistently safe and palatable supply.

2. Water quality should be protected to the extent required for reasonable water use by provision, as necessary, of sewage treatment, including adequate chlorination.

3. Secondary settling should be provided at all trickling filter installations.

4. Adequate waste treatment or reduction, or both, should be provided for industrial wastes as necessary to protect downstream water quality and use.

DESCRIPTION

Clear Creek arises on the eastern slope of the Continental Divide in the vicinity of Loveland and Berthoud Passes, Colorado, at elevations of 12,000 feet or more and flows in an easterly direction for approximately 70 miles to its junction with the South Platte River a short distance below the north city limits of Denver. The stream flows for most of its length through narrow rugged canyons from whence it emerges on the plains immediately above Golden, Colorado, less than 20 miles above its mouth. The stream bed was originally quite rocky, with steep slopes in excess of 200 feet per mile above Silver Plume. The original stream bed has been altered radically by mining operations and, at present, it is largely gravel and silt over much of the stream length. Stream slopes vary from a minimum of 30 feet per mile near the mouth to several hundred feet per mile in the headwaters.

Clear Creek is of historical interest in that it was the site of the first gold discovery in Colorado in 1859, which resulted in the opening of this area for settlement. Communities of Georgetown, Silver Plume, Empire, Central City, Blackhawk, Idaho Springs and Golden were prosperous mining camps before the turn of the century. These communities have since shrunk in size and importance until they are, at the present time, relatively small communities, existing largely on the tourist trade which has become a major industry in this area. The town of Golden is the largest community on Clear Creek and is the location of the Colorado School of Mines.

Elevations in the basin vary from about 12,500 feet in the headwaters to about 5,000 feet at the mouth. Temperatures, rainfall, and humidity are similar to those described for the higher elevations in the South Platte Basin.

PRESENTATION OF DATA

Public Water Supplies

Public water supplies serving an estimated 7,265 population are obtained from surface sources. Table C1-1 presented below lists these communities and their sources of supply.

Table C1-1 Public Water Supplies from Surface Sources

Community	Watershed	Source	Estimated Population Served	Treatment	Cap. MGD
Silver Plume	Clear Creek	Clear Creek	140	None	0.05
Georgetown	Clear Creek	Leavenworth Reservoir	400	Chlor.	--
Empire	W.Clear Cr.	Mad Creek	175	None	0.06
Idaho Springs	Clear Creek	Chicago Cr.	2,500	Filtered Chlorinated	0.25
Blackhawk	N.Clear Cr.	Springs	250	None	0.10
Central City	N.Clear Cr.	Springs	300	None	0.10
Golden	Clear Creek	Long Lake	3,500	Chlorinated	0.5

The watershed utilized by Idaho Springs for its supply is patrolled and is a popular tourist area leading to the summit of Mount Evans, one of the higher peaks in the Rocky Mountain chain with elevation in excess of 14,000 feet. The water is treated by filtration and chlorination before use. The water supply for Georgetown is obtained from Leavenworth Reservoir and passes through a power plant before being used by the town. This water receives chlorination before use. The Golden water supply is obtained from Long Lake. The watershed is protected and the supply is treated by chlorination before use. Blackhawk, Central City, Empire, and Silver Plume utilize surface water supplies.

Sources of Pollution

Table C1-2 summarizes the magnitude and location of significant sources of pollution discharged to Clear Creek.

Table Cl-2 Sources of Pollution - Clear Creek Sub-Basin

Source	Stream (a)	River Mileage Above Mouth	Sewered Pop.	Type of Treatment (b)	Estimated Population Equivalent BOD	
					Untreated	Discharged
Silver Plume	Cl	Cl 53.3	100	None	100	100
Georgetown	Cl	Cl 50.8	270	None	270	270
Idaho Springs	Cl	Cl 36.5	2,100	None	2,100	2,100
Central City	Cl-NF	Cl-NF 7.5	200	None	200	200
Golden	Cl	Cl 18.0	3,400	None	3,400	3,400
Ind. Waste	Cl	Cl 17.8	—	None	12,500	12,500
Ind. Waste	Cl	Cl 12.2	—	None	220	220
Arvada	R	Cl-R 1.0	1,400	P	1,400	980
Ind. Waste	Cl	Cl 7.2	—	None	1,860	1,860
Westminster	Cl	Cl 3.6	1,200	S	1,200	480[c]
Ind. Waste	Cl	Cl 1.8	—	None	320	320

(a)- Cl - Clear Creek; R - Ralston Creek; Cl-NF - North Fork Clear Creek.

(b)- P = Primary Treatment; S = Secondary Treatment.

(c)- No secondary settling provided.

The total estimated population equivalent of all untreated wastes of communities and industries along the streams is estimated at 23,600, of which 14,900 represents the contribution by industry. The sewage from all communities in the Clear Creek Basin, except Arvada and Westminster, is discharged to the streams without treatment. The population equivalent of the raw sewage discharged by these communities is estimated at 6,070. Arvada provides primary treatment for an estimated population of 1,400. Westminster provides secondary treatment for its wastes which reduces the estimated population equivalent from 1,200 to 480. The Westminster plant consists of a standard Imhoff-tank trickling-filter installation. The overall efficiency of this plant is reduced by failure to provide secondary settling for the trickling filter effluent, thus permitting the discharge of humus from the trickling filter to the stream with the plant effluent.

Industrial waste pollution is concentrated in the plains area about Golden. The major industry contributing wastes to the stream is a brewery located immediately east of Golden. It is estimated that the population equivalent contributed by this industry is 12,500. Other industrial wastes contributing sizeable population equivalent loads to the basin are meat packing plants located along the stream below Golden which have a combined estimated population equivalent of 2,400. The only other industrial wastes found in the basin are those resulting from mining and milling operations which do not contribute organic wastes to the stream. Table Cl-3 summarizes the industrial wastes discharged to the Clear Creek Sub-basin.

Table Cl-3 Industrial Wastes Summary - Clear Creek

Type of Industry	No. of Plants	Estimated Population Equivalent BOD
Brewery	1	12,200
Malted Milk	1	300
Meat Packing	3	2,400
Ore Mills	9[a]	—
al Mines		
(a) Intermittent Operation.		

Laboratory Results

The average results for summer and winter seasons, together with the major sources of pollution, are shown in Figure Cl-1. The laboratory results covering determinations of dissolved oxygen, B.O.D., and median coliform counts are shown for the main stem only. These data are also shown graphically on Figures 6, 8, and 10 for the summer season, and on Figures 7, 9, and 11 for the winter season. The values presented in the above figures are averages and do not show the most critical conditions at any given point. For this and other information, reference is made to the Summary of Individual Results appearing in Appendix "J", or to the Summary of Seasonal Results in Table 34.

Dissolved Oxygen

Dissolved oxygen does not appear to be a problem in Clear Creek. Both summer and winter averages are above 90% saturation even below sources of pollution. The high dissolved oxygen content of this stream is believed due to the relatively rough stream bed and the steep slopes which cause a high rate of air entrainment in the water.

B.O.D. Results

During the summer months the average B.O.D. is less than 1.0 above Golden. This value increases to 6.0 or 7.0 ppm immediately below Golden after which it levels off to approximately 3.0 ppm to the mouth of the stream. During the winter season the B.O.D. increase immediately below Golden is quite marked, reaching a value of 58.0 ppm on the north bank of the stream where the sewer outfall of Golden discharges. This value decreases to approximately 4.5 ppm at the mouth of the stream. The lower B.O.D. values obtained during the summer season are due in part to the much greater dilution afforded the wastes during this period. Reference to Table Cl-4, Frequency of Low Mean Monthly Discharges, will show that mean monthly flow during the summer may once in 10 years be less than 81 c.f.s. The low mean month of record at the gage above Golden shows a flow of 58 c.f.s. for the summer period. This is contrasted to a flow of 23 c.f.s. for the winter period.

Coliform Results

Median coliform values in Clear Creek above Idaho Springs are 230 per 100 ml. during the summer season and less than 100 per 100 ml. for the winter season. These values increase below Idaho Springs to nearly 10,000 per 100 ml. in the summer, and about 4,300 per 100 ml. in the winter season. Above Golden, the median coliform count is 2,300 per 100 ml. for the summer season, and 1,600 per 100 ml. for the winter season. Below the Golden sewer outfall, these values increase to 93,000 per 100 ml. during the summer season and to 1,500,000 per 100 ml. during the winter season. Median coliforms between Golden and the mouth remain in excess of 20,000 per 100 ml. during both summer and winter seasons.

Chemical Results

Copper determinations made on a few samples from Clear Creek below Golden show maximum values of 0.14 ppm. Hardness and alkalinity determinations were not made on samples taken from this creek, except in a few instances. For further information, reference is made to the Summary of Individual Results presented in Appendix "J".

Low-Flow Frequencies

Table C1-4 summarizes a study of low mean monthly flow frequencies during the period of record for 2 gaging stations located on the main stream. The period of record varies from 37 to 21 years. Low flows were computed for the summer period from May to September and for the winter period from October to April, which correspond roughly to irrigation and nonirrigation seasons. The effects of heavy diversion below Golden are easily seen in the considerable drop in stream flow recorded between these two stations.

322 b

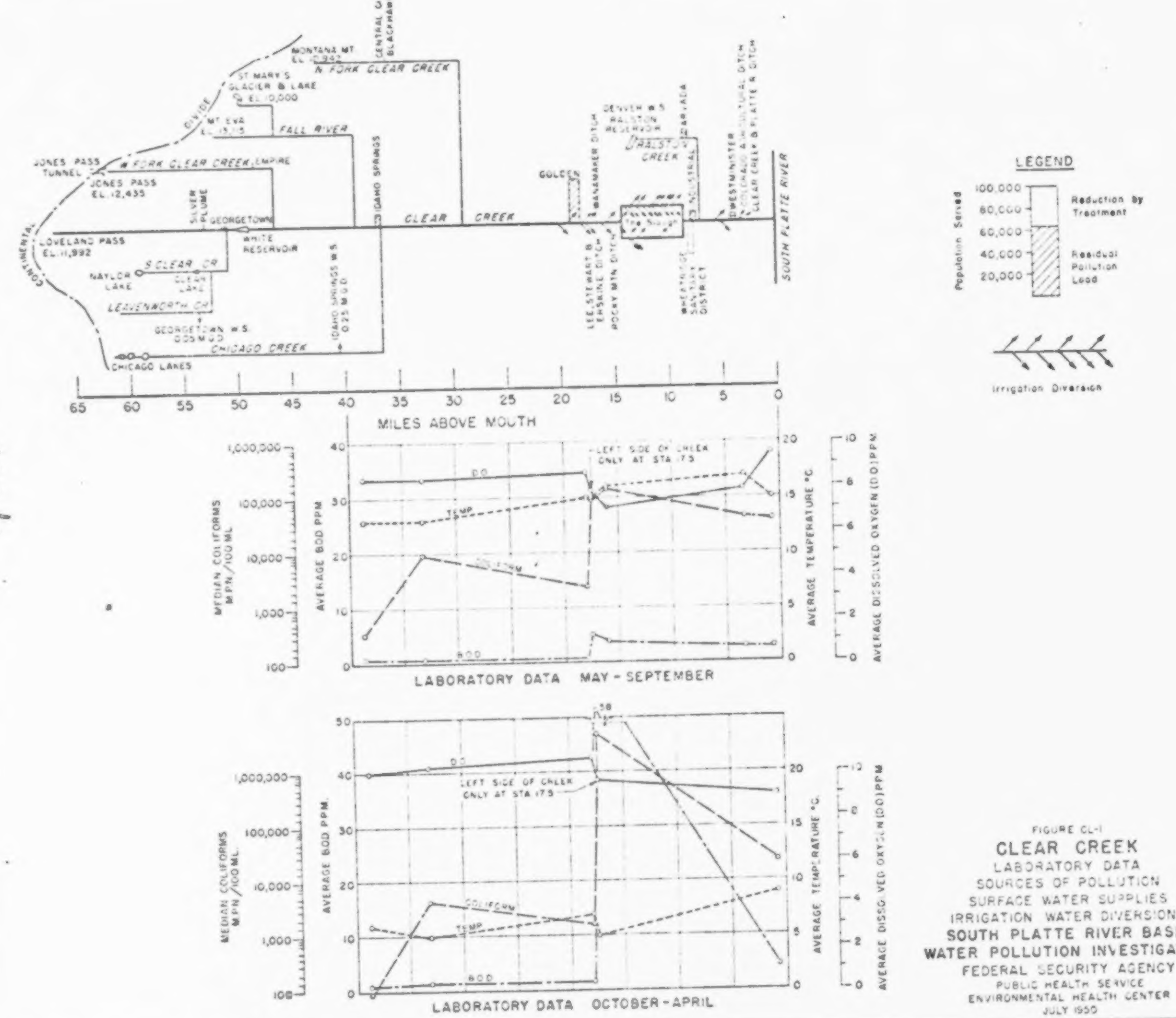


FIGURE CL-1

CLEAR CREEK
LABORATORY DATA
SOURCES OF POLLUTION
SURFACE WATER SUPPLIES
IRRIGATION WATER DIVERSIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
JULY 1950

Table Cl-4

Frequency of Low Mean Monthly Discharges
Clear Creek

Gaging Station Location on Clear Creek	Miles Above Mouth	Drainage Area in Square Miles	Years of Record	Values in Cubic Feet per Second Which the Mean Monthly Flow May Be Expected to Equal or to Be Less Than on the Average of Once in:								Low Mean Month of Record in Cubic Feet per Second	
				2 Years		3 Years		5 Years		10 Years			
				summer[a]	winter[b]	summer	winter	summer	winter	summer	winter	summer	winter
Seven Miles above Golden	27.3	392	37	132	37	112	32	94	28	81	23	58	23
Derby	0.7	600	21	8.6	7.2	6.5	5.8	4.6	4.4	3.0	2.8	1.3	2.5

a - Summer irrigation season: May 1 to September 30.
b - Winter non-irrigation season: October 1 to April 30.

DISCUSSION

Sewage Treatment Status and Needs

All sewered communities on Clear Creek, except Arvada and Westminster, discharge their wastes into the stream without treatment. Inasmuch as the waters of the Clear Creek Basin, particularly above Golden, are extensively used for recreational purposes, it is believed that a requirement of secondary treatment of sewage is a reasonable one. Further, the disinfection of the effluent before discharge, to control bacterial contamination of the receiving streams, should be carried out. Secondary treatment plus effluent chlorination should be provided by Silver Plume, Georgetown, Idaho Springs and Central City.

Because the waters below Golden are extensively used for irrigation purposes and because a large part of the truck crops grown in the Denver area is raised on lands irrigated by these waters, Golden sewage should receive suitable treatment. Plans are already under way to bring about the treatment, not only of the sewage from Golden, but also the industrial (brewery) wastes at this point. The industry will build and operate the treatment plant and treat the sewage from the city for a service charge based upon B.O.D. contribution. This is the reverse of the usual cooperative arrangement between a municipality and an industry. Preliminary information indicates that the plant, when constructed, will provide secondary treatment. Effective chlorination of the effluent should be carried out, in order to reduce the bacterial contamination, because of the irrigation usage below Golden.

Treatment plants of communities below Golden should provide for disinfection of their effluents at least during the irrigation season, to reduce bacterial contamination of the creek waters. The efficiency of the treatment plant at Westminster is reduced by the failure to provide for secondary sedimentation following trickling filters. This omission permits humus from the filter to be discharged to the stream along with the plant effluent. Arvada should provide secondary treatment plus effective effluent chlorination.

A new sanitation district is constructing a plant on Clear Creek above Ralston Creek junction. The effluent from this plant should be disinfected with chlorine. The formation of additional sanitation districts in the area northwest of Denver, similar to those at Westminster and Wheat Ridge, will increase the amount of wastes discharged to the lower creek. Since the bulk of the stream flow at Golden is diverted above Ralston Creek, the diminished flow in the lower stream stretch will require a high degree of sewage treatment.

Slaughterhouses discharging raw wastes to the Creek should provide treatment before such discharge.

Ore mills located along the Creek provide ponds for settling of tailings. Some of these ponds are located close by the creeks so that high stream flow causes erosion of the retaining dikes. These mills operate sporadically. Mine drainage is apparent from some tunnels along the creeks but the amounts are small and the creek appears able to handle them satisfactorily. Drainage from a large tunnel near Idaho Springs with a discharge of approximately 200 gallons per minute was analyzed and gave the following characteristics:

Copper (Cu)	44 ppm.
Iron (Fe)	348 ppm.
Lead (Pb)	0.125 ppm.
Hardness	12,000 ppm.
pH	2.5

The effects of these wastes upon the creek below the point of entry are negligible as determined by stream sample analyses. This is because of the great dilution afforded by the flow in the stream.

Irrigation Usage

Table C1-5 presents a summary of the dissolved oxygen, B.O.D. and coliform results at various irrigation diversions in Clear Creek below Golden. Diversions to Wanamaker, and to the Lee, Stewart and Eskins ditches occur immediately below the city. The Rocky Mountain Ditch diversion is approximately 1.5 miles downstream from the city. The Colorado Agricultural Canal diversion is near the mouth of the creek below Westminster. The effects of the sewage discharged into the creek are apparent. The need for disinfection of the sewage effluents is shown by the high bacterial numbers.

Recreational Usage

Because the Clear Creek basin is rich in historical western lore, it is a popular summer resort area. In fact, it is exploited to this end by such popular projects as the revitalization of Central City by means of the Central City Festivals held during the summer months. There does not appear to be any good reason why much of the main stream above Golden could not be reserved for fishing and other recreational purposes. Heavy

Table Cl-5 **Laboratory Results - Irrigation Ditches**
Clear Creek Sub-Basin

Station	Number Samples	Value	Dissolved Oxygen ppm.	Dissolved Oxygen % Sat.	B.O.D. ppm.	Coliform Bacteria per 100 ml. (MPN)
Wanamaker Ditch Cl 17.5L	17	Avg.	7.9	97	5.3	93,000*
		Max.	9.1	110	22.	930,000
		Min.	5.5	67	1.0	9,300
Lee, Stewart & Eskins Cl 17.5R	16	Avg.	7.9	98	6.8	93,000*
		Max.	8.9	109	>15.0	930,000
		Min.	6.4	84	1.9	23,000
Rocky Mtn Ditch Cl 16.1	13	Avg.	7.1	88	3.8	150,000*
		Max.	8.9	108	6.2	430,000
		Min.	5.2	64	1.6	9.300
Colorado Agricultural Canal Cl 3.4	12	Avg.	7.9	98	2.8	43,000*
		Max.	8.5	106	4.9	930,000
		Min.	7.2	89	1.2	9,300

* Median coliform value given instead of average.

stocking of the waters would probably be required each spring in order to provide sufficient fish for good angling. Long established irrigation usage below Golden, however, precludes the use of the stream below that point for recreational purposes.

Probable Effects of Project Operations

Under present plans the Blue-South Platte Project would deliver additional water to Clear Creek for irrigation purposes. The deliveries of project water to Clear Creek would be made below Golden, just north of South Table Mountain. It is anticipated that an average of 55,000 acre-feet per annum would be delivered to Clear Creek or directly to the canals supplied from Clear Creek. If no additional storage is constructed in the area, deliveries would be made during the irrigation season so as to produce minimum flows in Clear Creek at the point of delivery, as follows:

June..............	400 cfs.
July..............	150 cfs.
August............	100 cfs.
September.........	50 cfs.

The additional water would be diverted by existing ditches and would not increase the flow at the mouth appreciably. If additional storage reservoirs are constructed in the unit, water deliveries will be made during the winter months at an average rate of 125 cfs. With this method the water would not be delivered to Clear Creek but to the reservoirs directly.

Since all additional water supplied to Clear Creek will be diverted largely for irrigation use, there seems to be no likelihood that needs for sewage treatment as previously discussed in this section can be altered as a result of project operation.